SEASONAL AND SPATIAL STUDY OF OYSTER SPAT IN MOBILE BAY AND EAST MISSISSIPPI SOUND

(Thesis: ChongKoo Lee
University of Alabama)

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by

ChongKoo Lee

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Illustrations were prepared by Ms. Linda Lutz.

LIST OF ABBREVIATIONS AND SYMBOLS

Asb. pl.	Asbestos plate
^{o}C	degrees Centigrade
cm	Centimeters
H'	Species Diversity Index
# Ind.	Number of individuals
m	Meters
m^{-2}	1/Square meter
0.1 m^{-2}	1/0.1 meter square
mm	Millimeters
P	Probability
P_i	Proportion of i-th species
ppt (o/oo)	Parts per thousand

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INTRODUCTION

Mobile Bay is the second largest estuarine system and the largest open water bay on the upper Gulf Coast (Austin, 1954). The bay is a positive estuary and receives such large amounts of fresh water that productive oyster reefs are only located at the lower end of the bay near the Gulf. The circulation of the bay seems to favor a pattern found in other gulf coast estuaries in which the flooding tides move up the eastern shore and the ebbing tides generally favor the western shore (Austin, 1954). Ryan (1969) reports that this movement carries water of higher salt content further north along the eastern shore as evidenced by the penetration of natural oyster reefs farther up this shore.

In Mobile Bay and Mississippi Sound there are seasonal salinity cycles with an inverse relationship between salinity and river discharge. Wide fluctuations in river discharge and salinity may occur from year to year. During some years, flooding conditions, which normally occur between March and May, can severely depress the salinity values (Schroeder, 1977b). During low flow discharges, which normally occur between September and November, salinities rise to a high point (McPhearson, 1970; Schroeder, 1976; 1977a).

McPhearson (1970) indicates that both surface and bottom temperatures are dependent on atmospheric temperature and vary seasonally. The inflow of river water, the exchange of water with the Gulf, and the mixing of these waters by tides and winds are horizontal and vertical processes which influence the temperature in Mobile Bay and Mississippi

Sound. These factors operate to influence the temperature simultaneously and it is difficult to establish the single component contribution of any one factor. On a large scale, however, it should be noted that seasons of the year can be correlated with temperature within specific ranges.

The freshwater input to the estuarine system brings terrigenous clastics which are loosely called "silt" and which are generally monitored by measures of turbidity. As can be expected "silt transport" will fluctuate seasonally and be highest during periods of river flooding. Turbidity levels may also be high in shallow areas of the bay due to the resuspension of bottom sediments by wind-generated wave action (McPhearson, 1970; Schroeder, 1977c).

Mobile Bay is a very complex physical environment where events and processes can occur over short time scales and small distances (Schroeder, 1976). Therefore, routine sampling of either chemical or physical parameters, in spite of careful design, may fail to fully describe the environment, i.e. detect adverse water quality conditions.

The use of populations of benthic organisms as indicators of altered water quality may be a viable index of intermittent, seasonal or chronic silt and/or waste loading. Reish (1957) and McMahan (1972) have shown that certain benthic organisms, i.e. the polychaete Capitella capitata could be used to indicate sewerage pollution. However, Gaufin and Tarzwell (1952) suggest that single species may not be reliable indicators of "pollutants" because they may be reacting to other ecological factors which may limit or increase their individual success.

It is important to consider the synergistic effects of natural chemical, geological and physical parameters in population studies. For example Maurer and Watling (1973) found that the diversity of species of fauna associated with oyster communities decreased as a function of decreasing salinity (a natural synergistic phenomena). Cory (1967) also found that the number of species was highest downstream of the Patuxent River estuary, as was the salinity. According to Gunter (1961), salinity is a limiting factor to the distribution of many marine organisms, especially as it decreases, and lower limits are often quite sharp.

Changes in aquatic and marine community structure are a well-known consequence of altered water quality and chronic exposure (Grigg and Kiwala, 1970; Cairns and Dickson, 1971; Howmiller and Beeton, 1971; Cairns _et al_., 1972; Leathem _et al_., 1973). Cairns and Dickson (1971) further suggest that analysis of animal and plant communities may provide significant information on the character of the chronic waste.

Most forms of stress (natural and artificial) reduce the complexity of the aquatic ecosystem (Reish, 1961; Wilhm and Dorris, 1968; Cairns and Dickson, 1971; Boesch, 1972; Holland _et al_., 1973). Bottom fauna vary greatly in their sensitivity to various types of pollution. The introduction of a pollutant reduces the number of species by eliminating those most sensitive to the pollutant and consequently only those organisms that are little effected or immune to the adverse conditions survive. Those waste tolerant survivors increase in numbers because of the lack of competition and predation until checked by the amount of food and space available (Cairns and Dickson, 1971). For an example, a simplified community (consisting of a few species) might easily have half the individuals present wiped out when conditions become unfavorable for one species because of natural environmental changes. Cairns and Dickson (1971) also emphasize that tolerant organisms are found in both unpolluted and polluted situation and that their presence does not mean a body of water is polluted. However, a population of pollution-tolerant organisms occurring in the absence of sensitive species is a good a priori indicator of the chronic presence of altered water quality.

With this information in mind, this study was undertaken to determine the relationships that exist between settling organisms at two stations which are near closed extant oyster reefs in upper mid-Mobile Bay and two stations at the boundary with East Mississippi Sound which are in the center of open extant reefs in lower Mobile Bay. The focal point would be an assessment of the change, if any, from the data of Hoese et al. (1972) and evaluation of existing oyster culture conditions over the extant closed reef communities.

MATERIALS, METHODS AND STUDY AREA

Four sampling stations were established in Mobile Bay. The location of the sampling stations corresponded closely with those of Hoese et al. (1972) so that comparisons could be made. Figure 1 and Table 1 indicate the locations of oyster reefs and sampling stations.

Collecting methods, modified from Hoese et al. (1972), utilized 0.1 m^2 asbestos plates which were placed on a marine plywood support suspended on creosoted pilings (Fig. 2). At each sampling station a sampling board holding a total of 16 plates (each plate measuring 10 cm x 10 cm) was placed at three levels. The levels of the sampling boards were: (a) 30-50 cm below the surface (the mean tide level), (b) 30 cm off the bottom, and (c) a third board at the middle level. Plates on the sampling boards were placed back to back so that for each sampling board 8 plates were oriented to the surface (up) and 8 plates faced the bottom (down) (Fig. 2). On every plate surface, 100 compartments of 1 cm^2 were scribed in order to facilitate the counting of all of the numbers of species and individuals on the plates. Plates were held in place by 2.5 cm aluminum angles which in turn were held by 6.4 mm surgical rubber tubing. The boards were suspended from eyebolts in the piling by stainless steel cable.

At all stations, water quality parameters (salinity, temperature, and Secchi Disc visibility) were measured at surface, middle and bottom water using available instrumentation (Beckman RS5-3 Salinometer and Secchi Disc).

Figure 1. Location of oyster reefs and sampling stations (Δ) in Mobile Bay, Alabama.

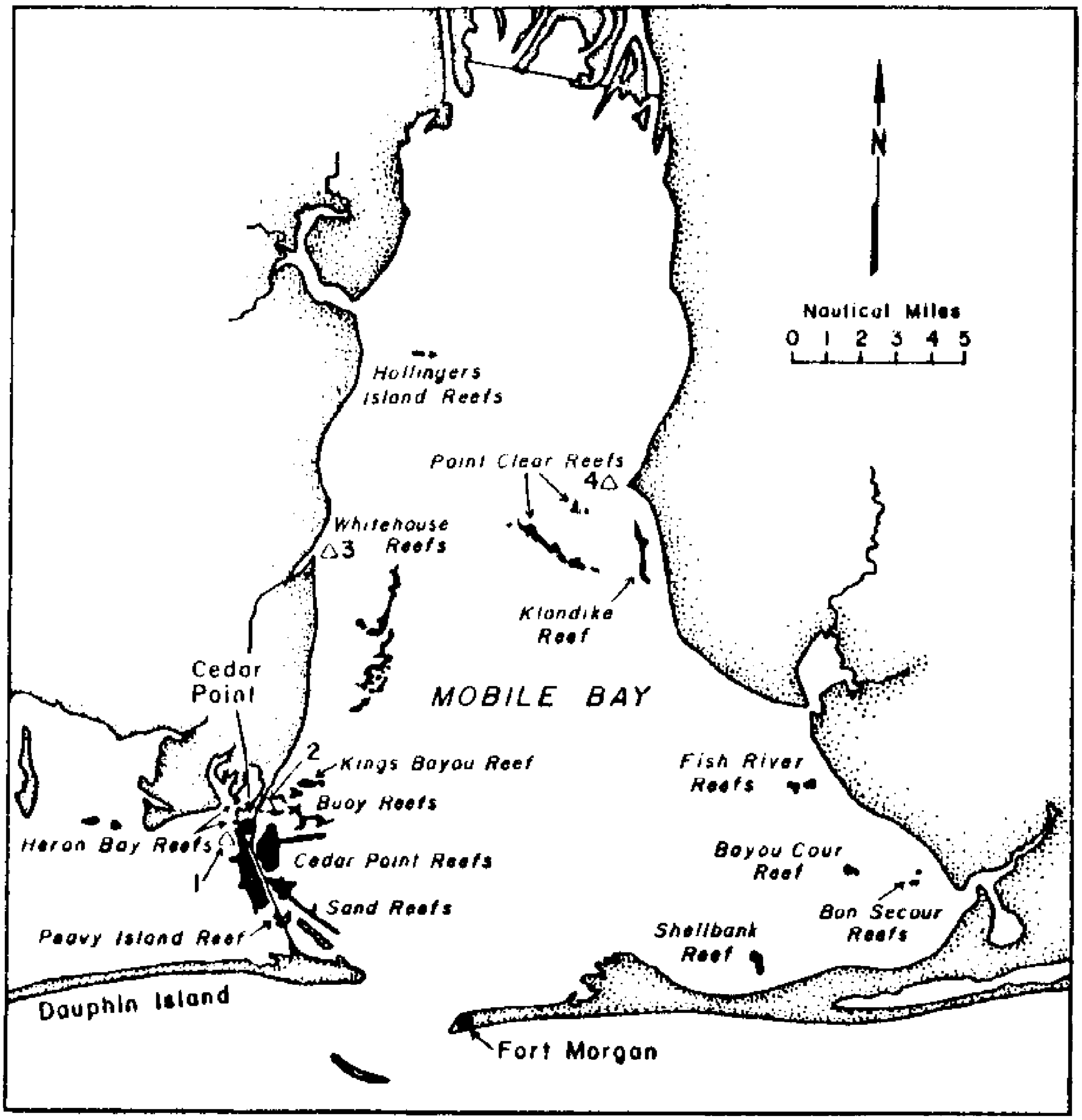

Nautical Miles
0 1 2 3 4 5
N
Hollingers
Island Reefs
Point Clear Reefs
4
Whitehouse
Reefs
3
Klondike
Reef
Cedar
Point
MOBILE BAY
2
Kings Bayou Reef
Buoy Reefs
Heron Bay Reefs
Cedar Point Reefs
1
Sand Reefs
Peavy Island Reef
Fish River
Reefs
Bayou Cour
Reef
Bon Secour
Reefs
Shellbank
Reef
Dauphin Island
Fort Morgan

Figure 1.

TABLE 1. Location of Sampling Stations.

Station number	Location
1	30^{o} 18' N 088^{o} 08' W
2	30^{o} 19' N 088^{o} 07' W
3	30^{o} 26' N 088^{o} 05' W
4	30^{o} 28' N 087^{o} 57' W

Figure 2. Configuration of sampling device containing three sets of asbestos plate sampling boards (above); a single asbestos plate sampling board (below).

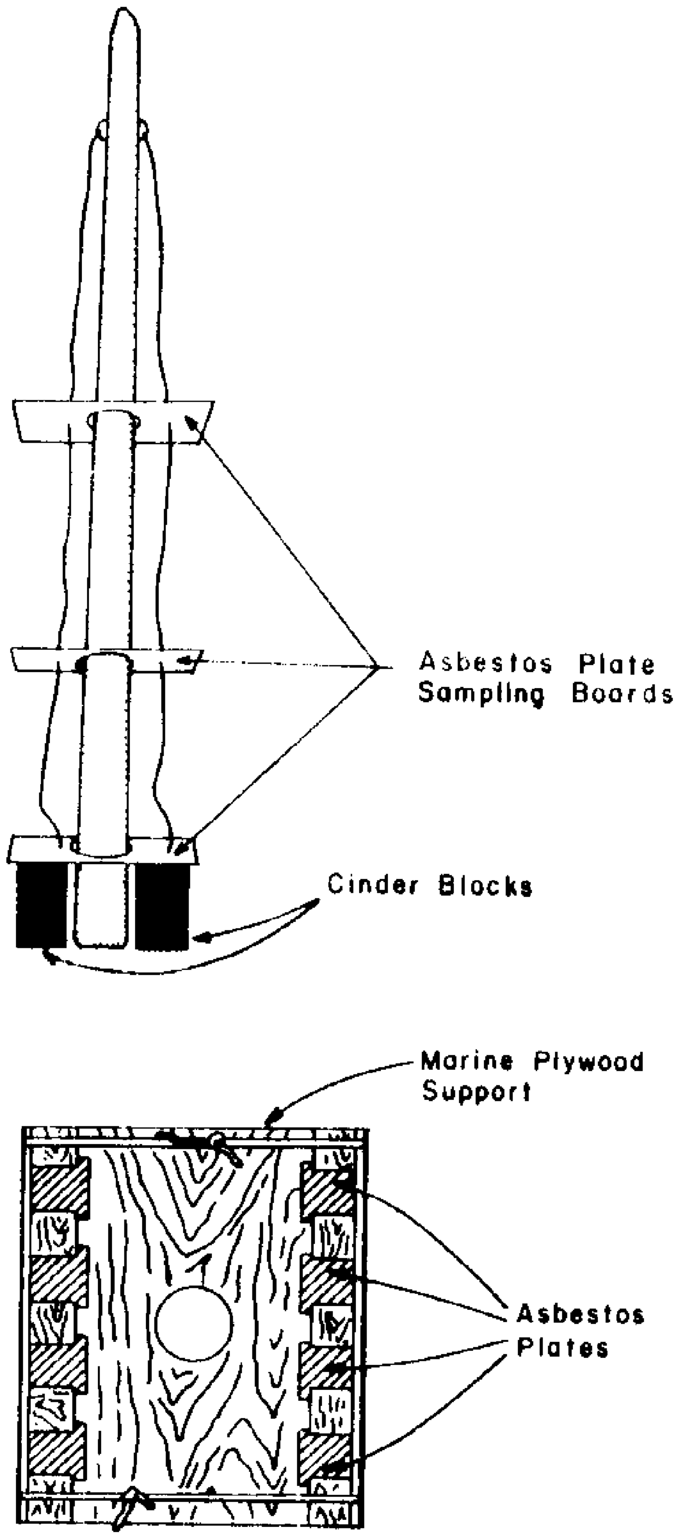

Asbestos Plate
Sampling Boards
Cinder Blocks
Marine Plywood
Support
Asbestos
Plates

Figure 2.

Beginning on June 10, 1977 and continuing to June 9, 1978, asbestos plates were to be removed every two weeks to collect four sets of plates at three levels at four stations; new ones were to be inserted in their place. Four sets of plates on each sampling level were to be undisturbed for one year for (a) continued studies of growth patterns, and (b) for the purpose of identification of settling organisms. Cold and foul weather, however, made it difficult to take samples at exactly two week intervals. Consequently, sampling intervals ranged from 10 days to 35 days and averaged 17 days.

On every sampling date, four sets (8 plates) out of eight sets (16 plates) of asbestos plates from each level were removed and placed in plastic bags and fixed with 5% formalin <u>in situ</u> and/or at the laboratory as circumstances dictated. Using a dissecting microscope, the mean and total number of each organism were computed per unit area. All invertebrates with the exceptions of barnacles and oysters were removed and transferred to alcohol for preservation and identification.

In this study, the Shannon-Wiener (Shannon and Weaver, 1949) information index was used as a primary measure of species diversity:

$$H' = -\Sigma\, p_i \log p_i$$

where p_i is the proportion of the i-th species. Fager's SDN index was used as a measure of evenness:

$$SDN = N(S + 1)/2 - \Sigma\, R_i n_i$$

$$\text{Scaled SDN} = (\text{Max.} - \text{Cal.})/(\text{Max.} - \text{Min.})$$

where S = number of species; N = number of individuals; R_i = order of species by decreasing abundance.

Friedman's nonparametric ANOVA (Friedman's method for randomized blocks) was used to test the significances between levels, stations and times (sampling periods) for number of species, number of individuals and diversity (H'). Wilcoxon's signed ranks test was used to determine the significances between upper surface and lower surface of sampling plates in terms of individuals (Sokal and Rohlf, 1969).

RESULTS

Physical

Water temperature - No pronounced difference in the water temperature within the water column was observed between the four sampling stations. An approximate 3°C difference between surface, mid-level and bottom water occurred at station 2 on September 23, 1977, station 3 on September 8, 1977 and January 6, 1978 and station 4 on March 31, 1978 (Fig. 3-5; Appendix A).

The warmest water temperature during the sampling period was 32°C in late June 1977 at stations 2 and 3. From this period to late September 1977, water temperatures ranged from 28 to 30°C. After the end of September, water temperatures decreased with a temperature of 22°C recorded in early October 1977. This cooling trend continued until early February 1978. The coolest water temperature recorded was 5°C on February 10, 1978. Temperature tended to increase continuously from February 10 until June 1978 although a "lag phase" occurred from April 4 through May 16, 1978 (Fig. 3-5; Appendix A).

Salinity - Salinity differences were observed between the surface and bottom layers of the water column at all stations. Salinity differences of approximately 10 ppt existed on September 8, November 23, 1977 and February 10, 1978 at stations 2, 4 and 4 again respectively (Fig. 6-8).

Slight differences existed in bottom salinities at stations 3 and 4. No such differences, however, were observed in surface salinities

Figure 3. Temperature of surface water at sampling stations from June 1977 to June 1978.

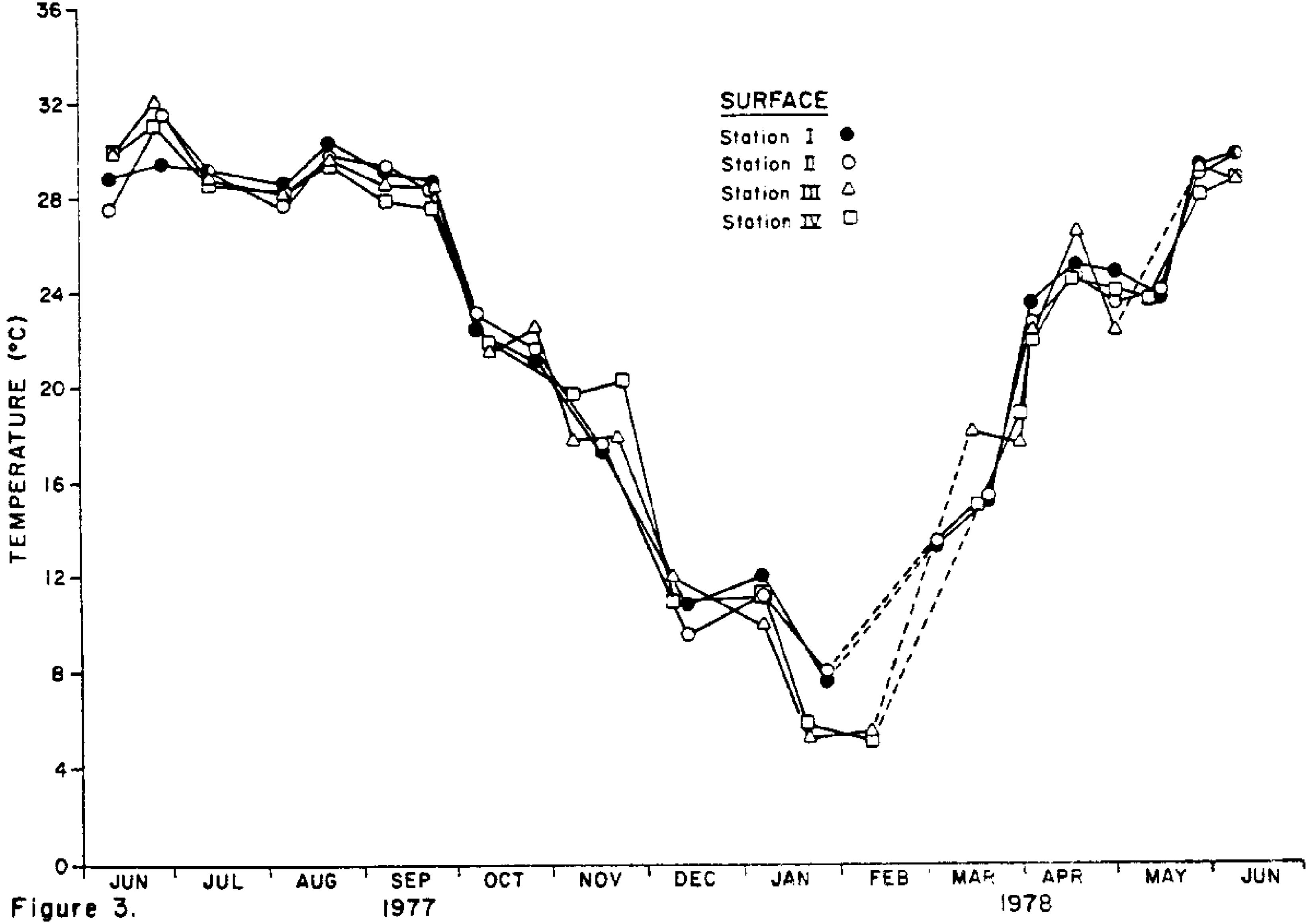

SURFACE
Station I ●
Station II ○
Station III △
Station IV □
TEMPERATURE (°C)
36
32
28
24
20
16
12
8
4
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 3.

Figure 4. Temperature of mid-level water at sampling stations from June 1977 to June 1978.

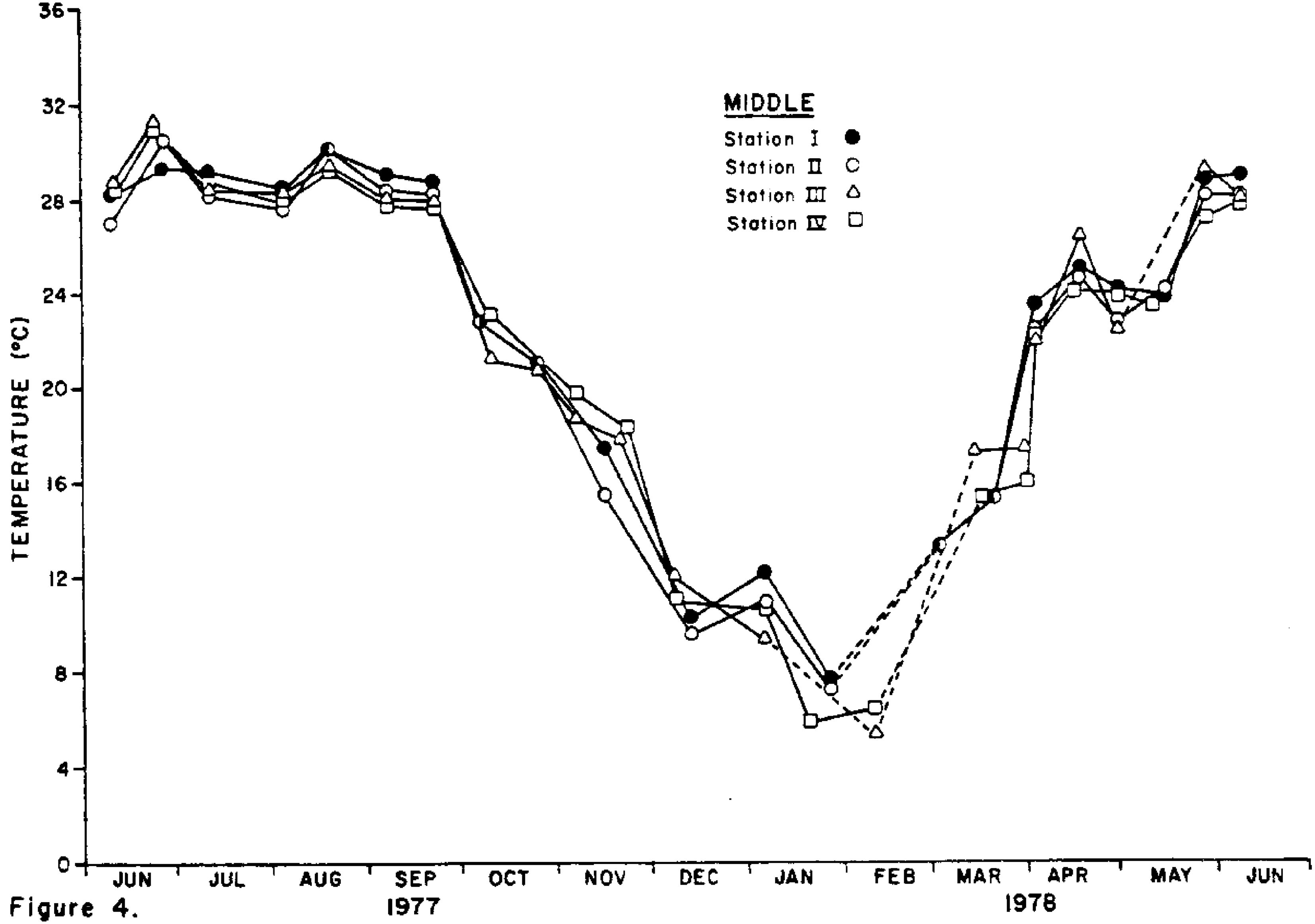
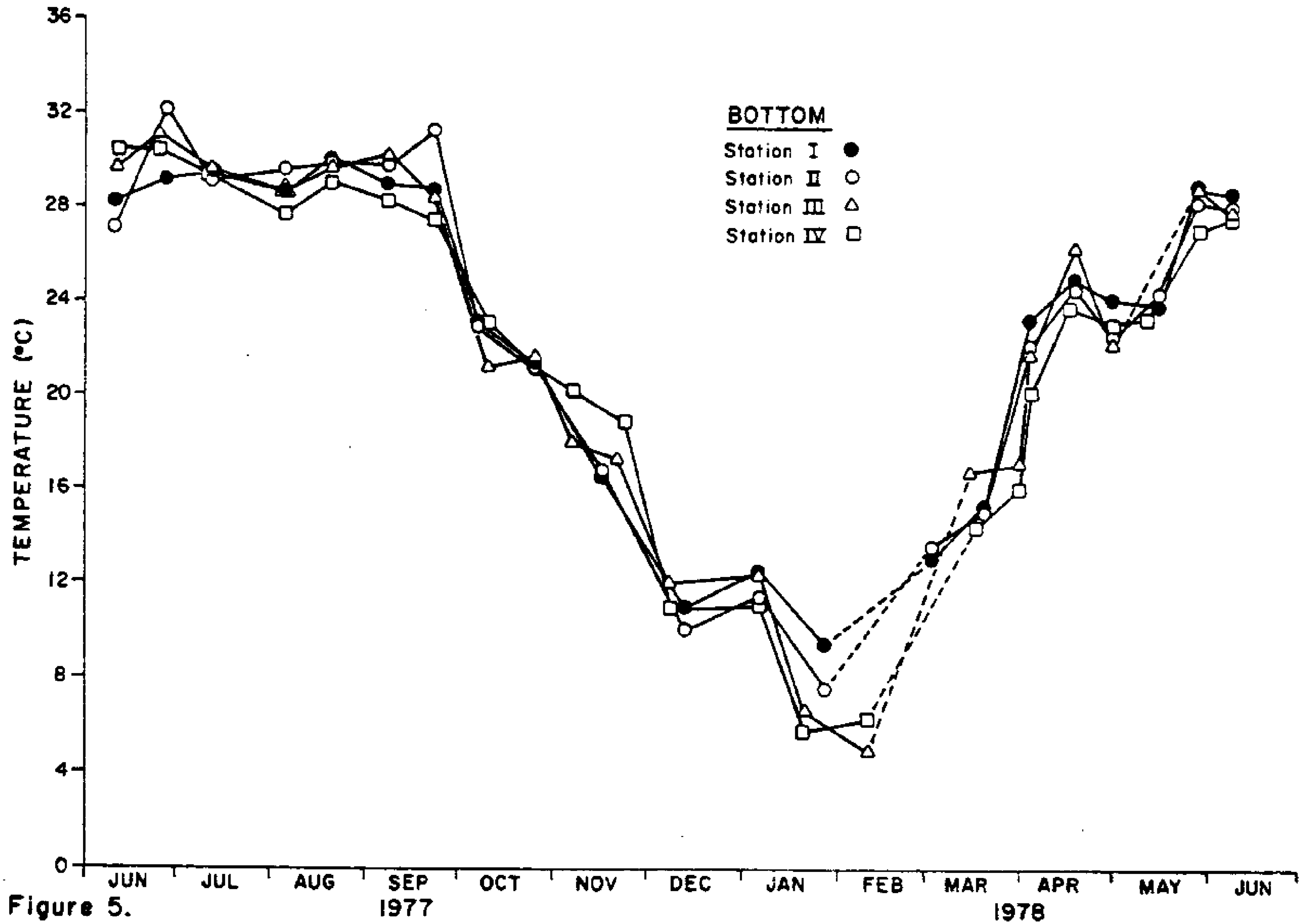

MIDDLE
Station I
Station II
Station III
Station IV
TEMPERATURE (°C)
0
4
8
12
16
20
24
28
32
36
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 4.

Figure 5. Temperature of bottom water at sampling stations from June 1977 to June 1978.



BOTTOM
Station I
Station II
Station III
Station IV
TEMPERATURE (°C)
36
32
28
24
20
16
12
8
4
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 5.

Figure 6. Salinity of surface water at sampling stations from June 1977 to June 1978.

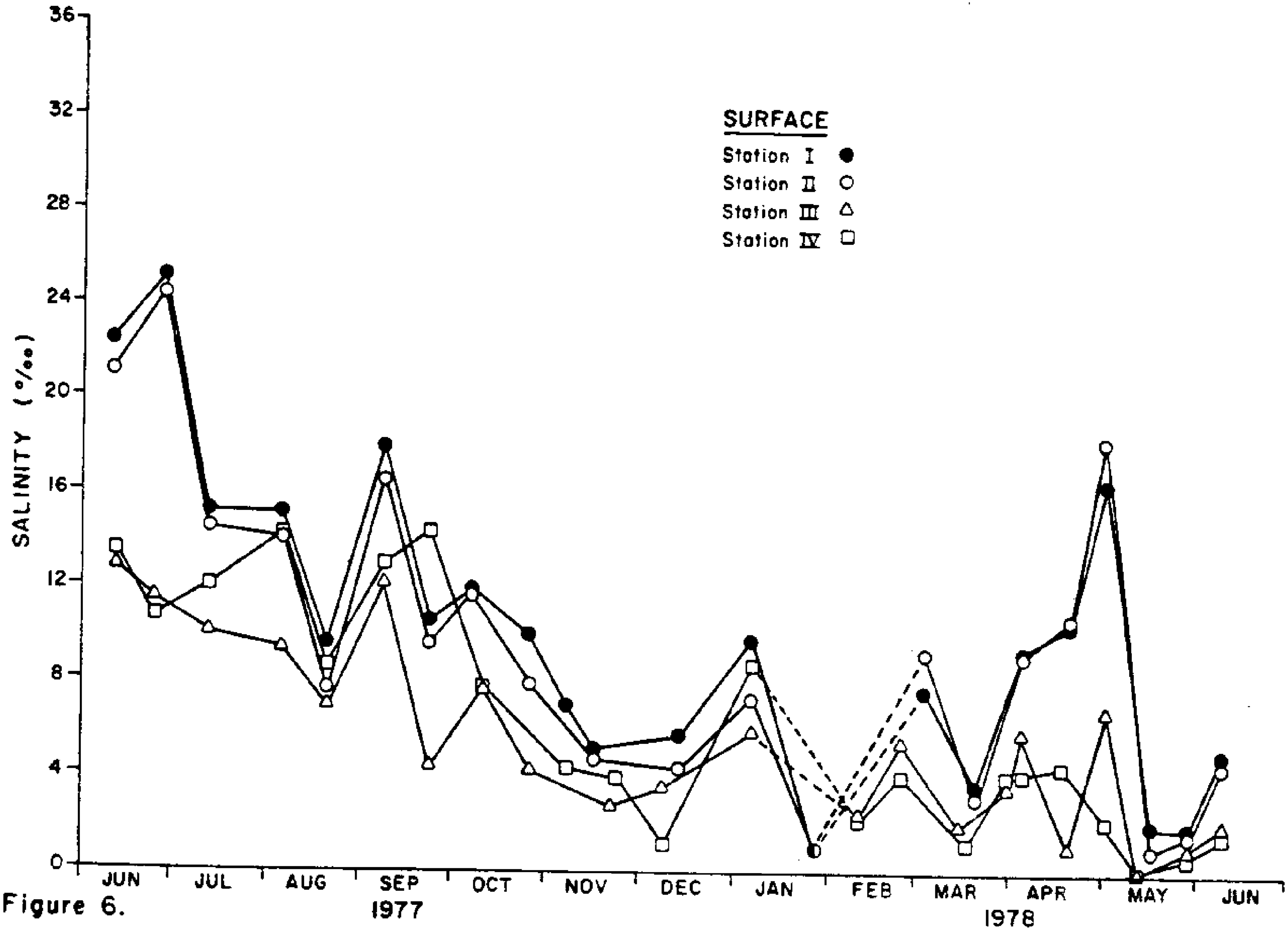

SURFACE
Station I
Station II
Station III
Station IV
SALINITY (‰)
36
32
28
24
20
16
12
8
4
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 6.

Figure 7. Salinity of mid-level water at sampling stations from June 1977 to June 1978.

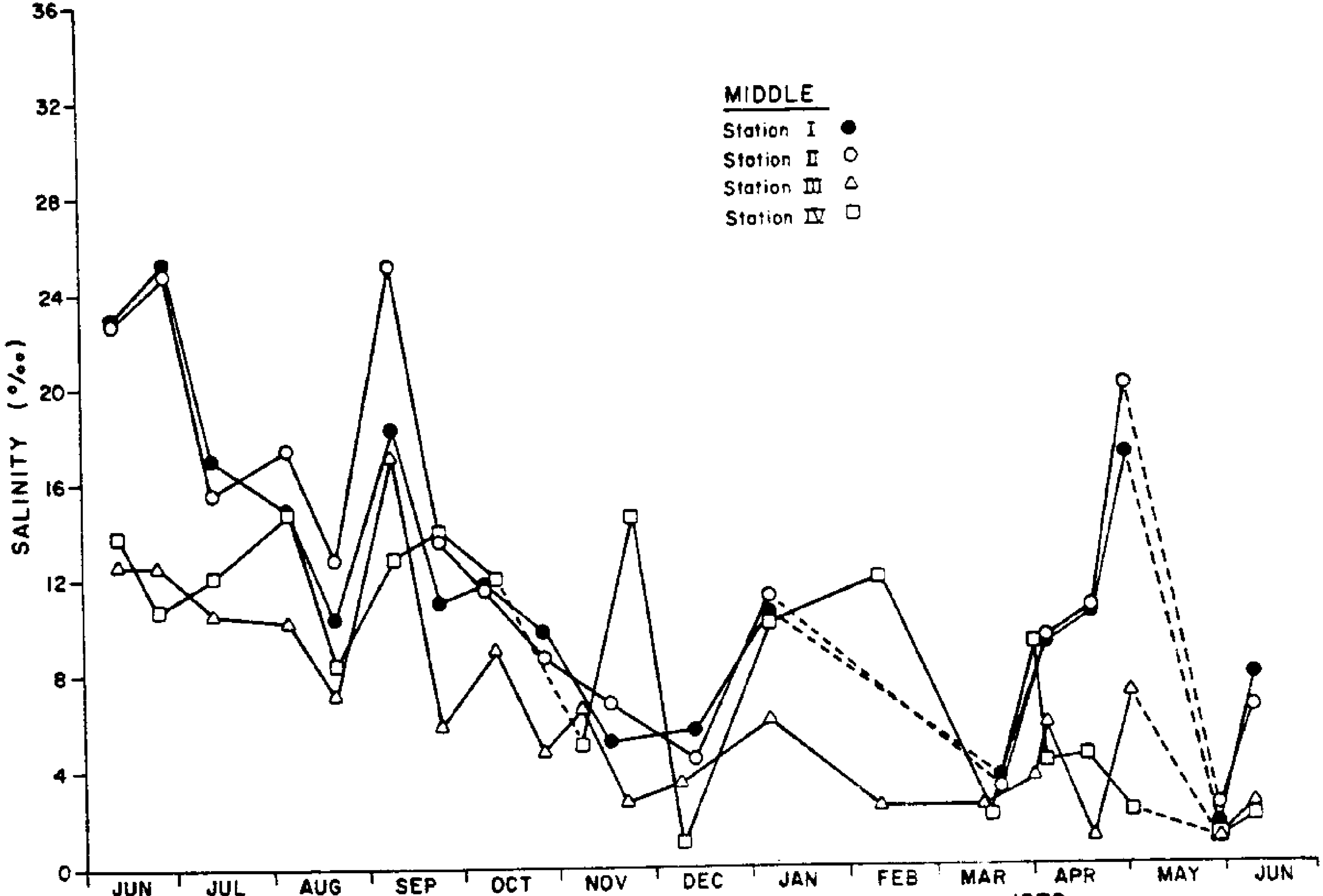

MIDDLE
Station I ●
Station II ○
Station III △
Station IV □
SALINITY (‰)
36
32
28
24
20
16
12
8
4
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 7.

Figure 8. Salinity of bottom water at sampling stations from June 1977 to June 1978.

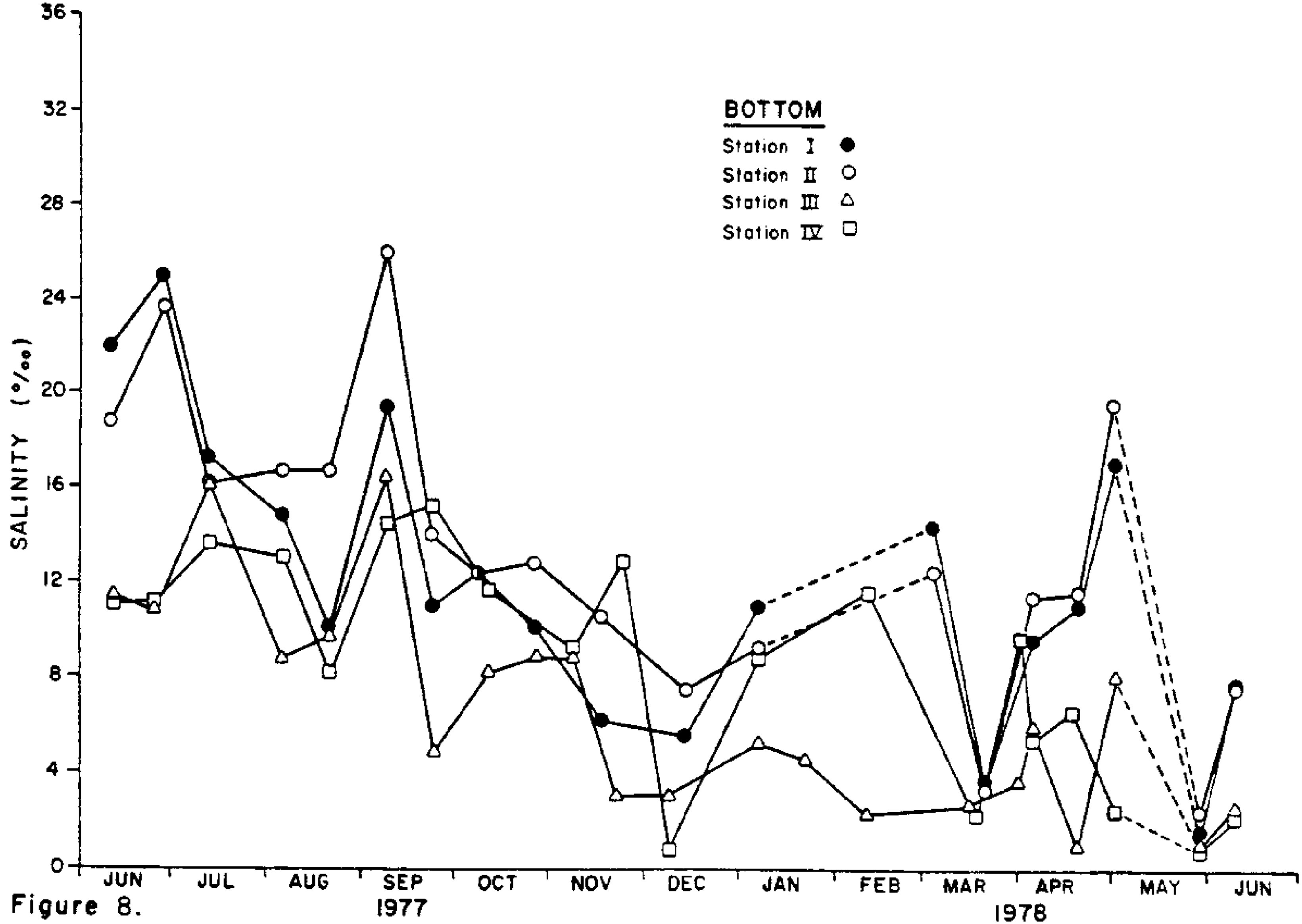

BOTTOM
Station I ●
Station II ○
Station III △
Station IV □
SALINITY (°/oo)
36
32
28
24
20
16
12
8
4
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 8.

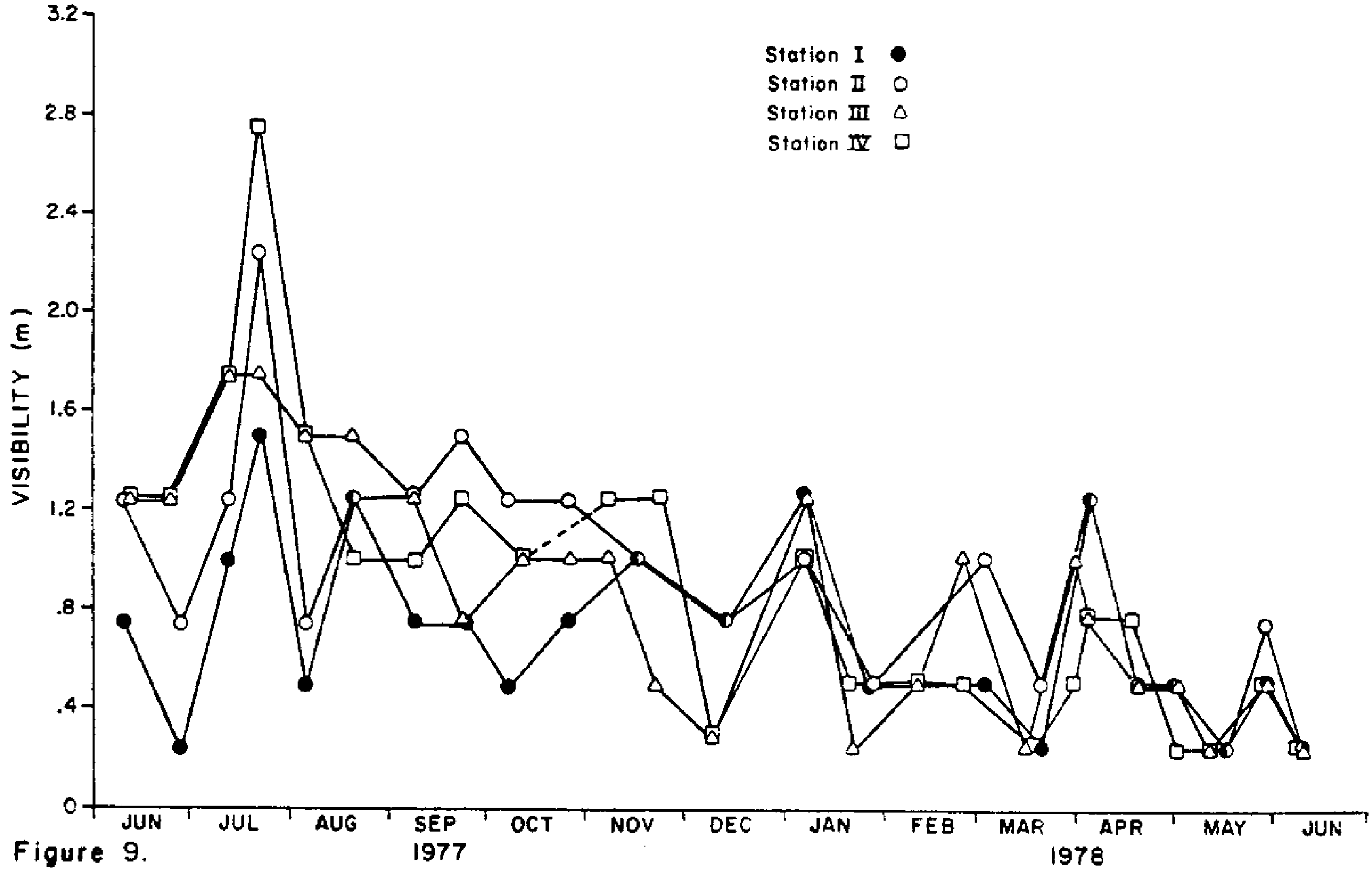
between the two stations. Salinity differences were recorded along the north-south gradient, with the salinities at the lower two stations (1 and 2) being slightly higher than the upper two stations (3 and 4).

In this study, salinities ranged from 0 to 26 ppt over the entire sampling period (Fig. 6-8). Station 1, the southern-most station near the Dauphin Island Bridge, had the second highest average salinity among four stations (11.4 ppt). The highest average salinity (11.8 ppt), however, was observed at station 2, located approximately one mile north from station 1. The lowest and next to the lowest average salinities occurred at station 3 (6.2 ppt) and station 4 (7.7 ppt) respectively.

<u>Secchi Disc visibility</u> - In general, fluctuation of visibility was found at all sampling stations (Fig. 9). Since variations in wind and wave action existed and the depths around sampling stations were quite shallow (approximately 3 m or less), the fluctuation in visibility at all stations was not surprising. On July 22, 1977 Secchi Disc visibility at all stations reached its peak, ranging from 1.5 to 2.75 m.

No apparent differences in visibility were found between eastern (station 4) and western (station 3) sampling stations throughout the sampling periods except in late July 1977. Strong similarity in the Secchi Disc visibility at the four sampling stations from December 1977 through June 1978 (Fig. 9) seemed to be the result of strong wind action and relatively large amount of precipitation coupled with the resultant river discharge during this period of time. Station 2 was found to have the highest average visibility among four stations (1 m), followed by station 3 (East Fowl River) and station 4 (Great Point Clear) with an average of 0.9 m. Station 1 showed the lowest value with $\bar{x}$ = 0.7 m.

Figure 9. Secchi Disc visibility at sampling stations from June 1977 to June 1978.



Station I
Station II
Station III
Station IV
VISIBILITY (m)
3.2
2.8
2.4
2.0
1.6
1.2
.8
.4
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 9.

Biological

Seasonal and spatial distributions of colonizing organisms - The following narrative follows the order of presentation given in Table 2. This table summarily describes the taxa encountered during this study and gives an indication concerning the occurrence of each taxa over the study period.

Phylum Coelenterata

Class Hydrozoa

Hydroids - Except for the time period from December 1977 through March 1978, hydroid colonies occurred at stations 1 and 2 throughout the sampling period. More hydrozoans were observed at the higher salinity stations (1 and 2) than the lower salinity stations (3 and 4) during the study period (Table 2).

Phylum Platyhelminthes

Class Turbellaria

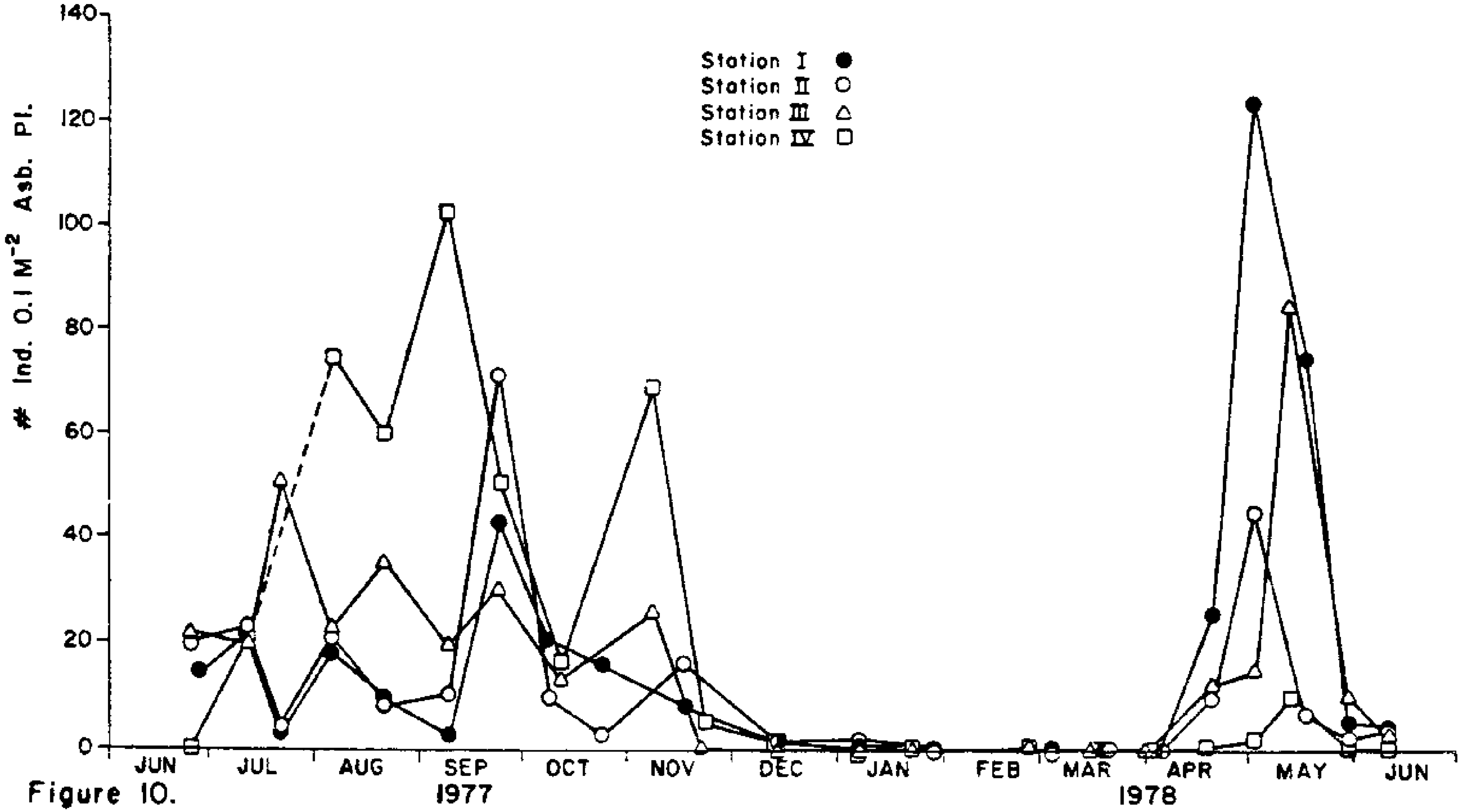
Stylochus spp. - At least one peak of *Stylochus* spp. was observed from July through November 1977 at each sampling station. Another peak period was observed during the sampling period from April through May 1978 (Fig. 10).

Both *Stylochus* sp. A and *Stylochus* sp. B were found at stations 1 and 2. Only a few specimens of *Stylochus* sp. B were collected at these stations from June through July 1977. Only *Stylochus* sp. A was collected at the lower salinity stations, 3 and 4 (Table 2). Station 1 had the lowest count for this species in 1977, and the highest number of the species during late April 1978. On the other hand, station 4 which had the highest number of *Stylochus* sp. A in 1977 showed the lowest number for

TABLE 2. Occurrence and Distribution of Taxa from Four Sampling Stations in Mobile Bay.
Legend: VC = 66 to 100% occurrence during 21 sampling periods
C = 33 to 65% "
R = up to 32% "
O = no occurrence "

Taxa	Station Number 1	2	3	4
Phylum Coelenterata				
Class Hydrozoa	VC	VC	C	R
Phylum Platyhelminthes				
Class Turbellaria				
Stylochus sp. A	VC	VC	VC	VC
Stylochus sp. B	R	R	O	O
Phylum Rhynchocoela				
Class Enopla	C	C	O	O
Phylum Annelida				
Class Polychaeta				
Polydora websteri	VC	VC	VC	VC
Neanthes succinea	VC	VC	VC	VC
Autolytus dentalius	R	R	O	O
Podarke obscura	O	R	O	O
Class Oligochaeta	R	R	R	O
Phylum Mollusca				
Class Gastropoda				
Thais haemastoma	O	R	O	O
Doridella sp.	R	R	R	R
Unidentified opisthobranch	C	VC	C	C
Class Bivalvia				
Crassostrea virginica	C	C	R	R
Ischadium recurvum	VC	VC	VC	VC
Mytilopsis leucophaeata	O	O	O	R
Phylum Arthropoda				
Class Crustacea				
Subclass Cirripedia				
Order Thoracica				
Balanus eburneus	VC	VC	VC	VC
Subclass Malacostraca				
Order Amphipoda				
Melita nitida	VC	VC	C	R
Melita sp.	C	VC	O	R
Gammarus spp.	O	O	R	R
Grandidierella bonneroides	R	R	O	O
Corophium lacustre	C	C	VC	VC
Paracaprella cf. *pusilla*	R	R	O	O
Order Decapoda				
Eurypanopeus depressus	C	VC	R	R
Callinectes sapidus	R	R	R	R
Class Insecta				
Order Diptera				
Unidentified midge	O	O	R	R
Phylum Bryozoa				
Class Gymnolaemata				
Membranipora sp.	VC	VC	C	C

Figure 10. Average number of *Stylochus* spp. at sampling stations.



140
120
100
80
60
40
20
0
Ind. 0.1 M^{-2} Asb. Pl.
Station I ●
Station II ○
Station III △
Station IV □
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 10.

the species during 1978. During the period from December 1977 through April 1978 the number of Stylochus spp. approached zero (Fig. 10).

Phylum Rhynchocoela

Class Enopla

Rhynchocoels - Unidentified rhynchocoels occurred at only the two lower bay stations (1 and 2) from late July through December 1977, and during April 1978 (Table 2). Not a single specimen was recorded between January and March 1978.

Phylum Annelida

Class Polychaeta

Polydora websteri (Blister worm) - Although three peaks are evident, pronounced peaks of Polydora websteri occurred in September 1977 and April 1978 at station 3 (Fig. 11). The highest average number of Polydora (443 0.1 m^{-2} asb. pl.) was found at this station during the sampling period from September 8 to September 23, 1977. The second highest number also occurred at this station during the sampling period from March 31 to April 19, 1978 (413 0.1 m^{-2}). The number of Polydora tended to increase from June through October 1977 although fluctuations in numbers were observed. After the sampling period from September 23 to October 11, 1977, the number of this species declined and almost reached zero in December 1977. No increase in numbers was recorded until April 1978. After the number of Polydora reached its peak during April 1978 at 413 0.1 m^{-2}, it tended to decrease again, reaching 20 0.1 m^{-2} in June 1978.

During August 1977 and April 1978 station 4, one of the upper bay stations, showed two peaks which were much smaller than those of station 3 (Fig. 12). The average number of Polydora websteri at the

Figure 11. Number of *Polydora websteri* set at station 3 at three different levels (surface, middle and bottom).

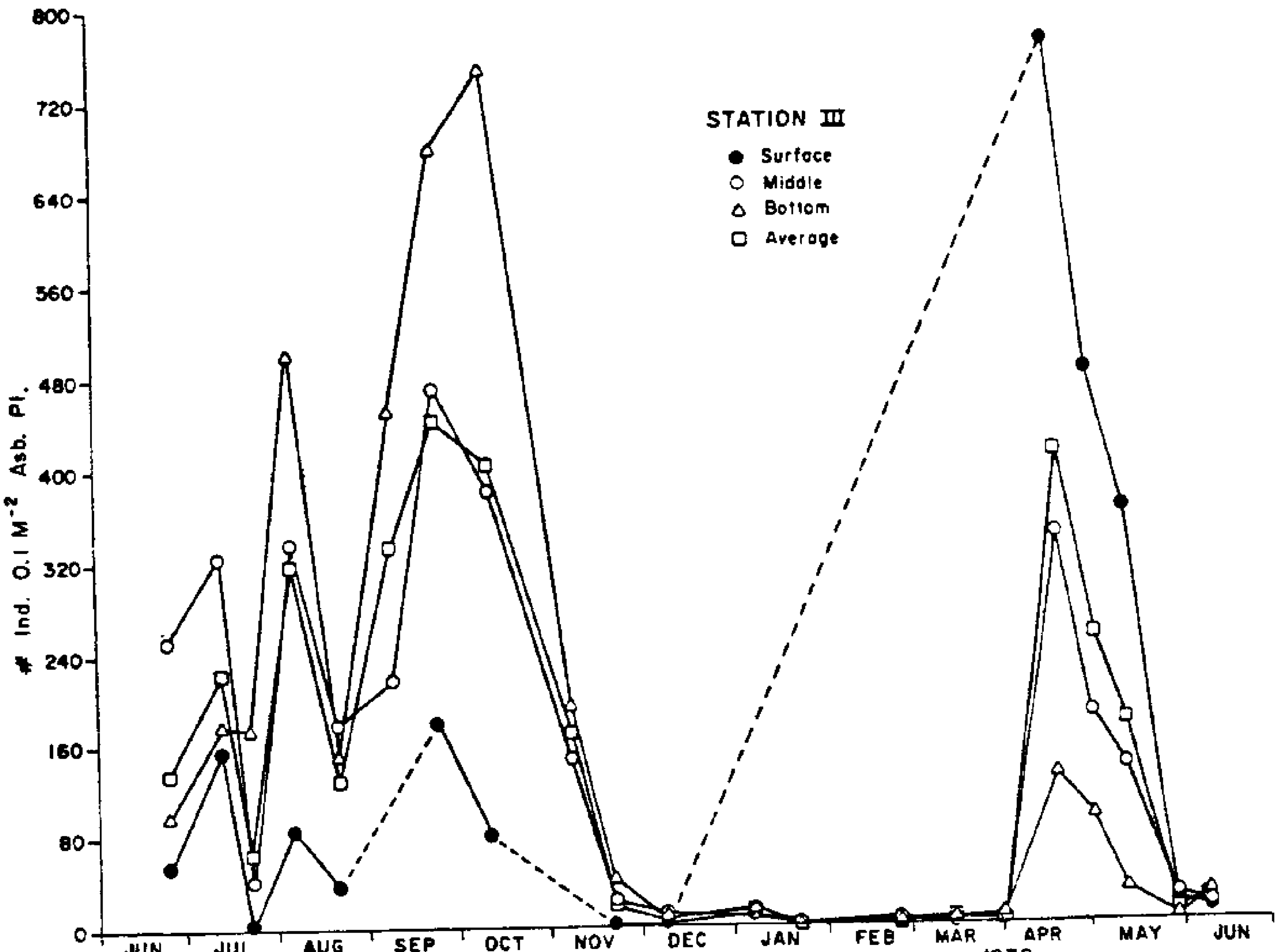

STATION III
Surface
Middle
Bottom
Average
Ind. 0.1 M⁻² Asb. Pl.
800
720
640
560
480
400
320
240
160
80
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure II.

Figure 12. Average number of Polydora websteri set at station 1, station 2 and station 4.

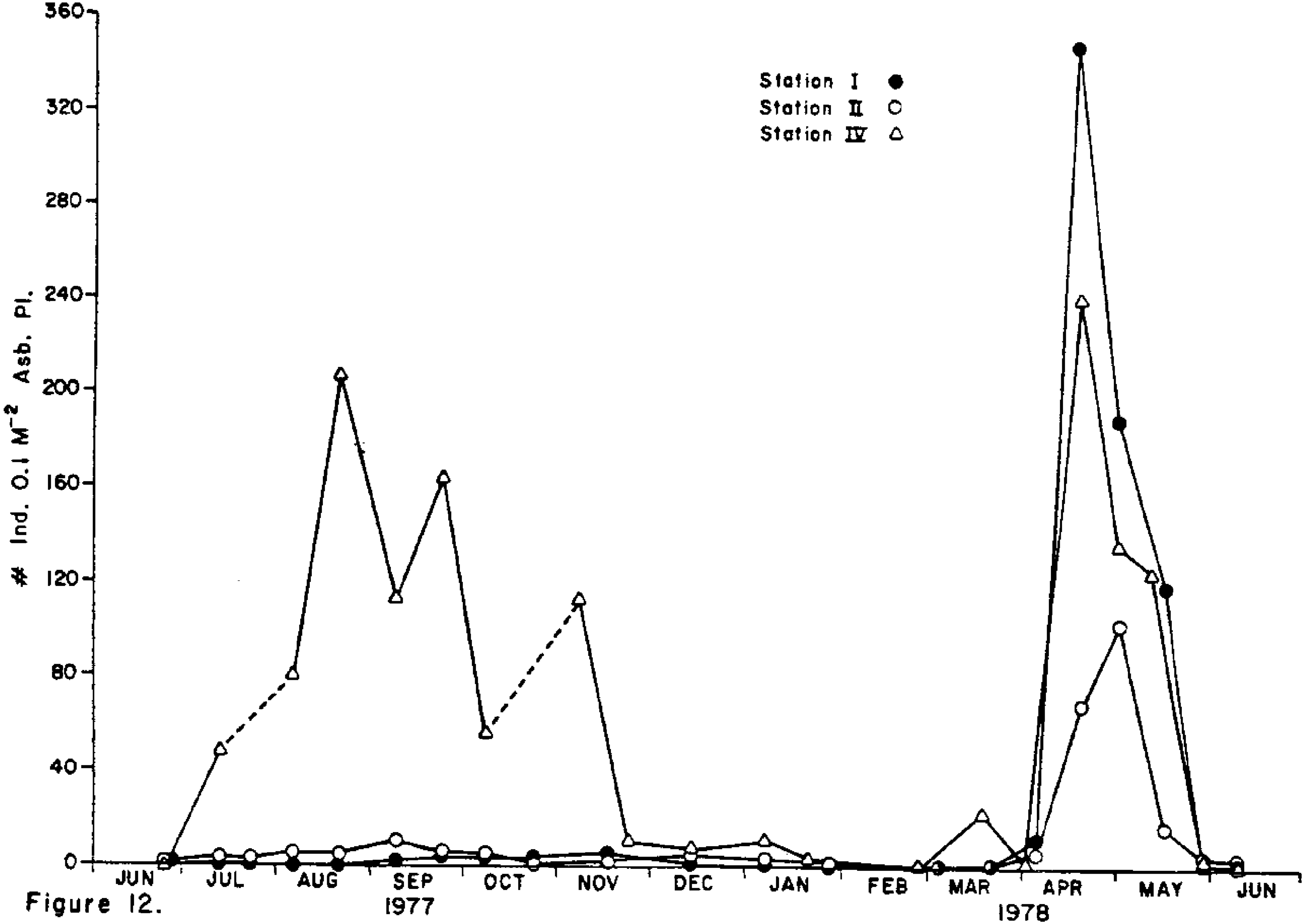

Station I
Station II
Station IV
Ind. 0.1 M^-2 Asb. Pl.
0
40
80
120
160
200
240
280
320
360
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 12.

lower bay stations (1 and 2), particularly station 1, increased suddenly during April through May 1978. At station 1, it reached 360 0.1 m^{-2} during April 1978; no more than 10 individuals 0.1 m^{-2} occurred at these stations during the remainder of the sampling period (June 1977-March 1978; June 1978).

Neanthes succinea (Oyster worm) - This worm was a commonly occurring species at all sampling stations (Table 2). The highest number of this species (354 between two 0.1 m^{-2} asb. pl.) was found at the middle level of station 3 between June 24 and July 12, 1977. During this period of time, an average of more than 50 worms (between two 0.1 m^{-2} plates) occurred at all four stations. There were two peaks between June and November 1977 at all stations and one small peak seemed to occur during May 1978 only at station 1. The number of Neanthes succinea tended to decrease at all stations with decrease in water temperature. From December 1977 through April 1978, no more than 5 individuals were encountered between two 0.1 m^{-2} plates at any station (Fig. 13).

Autolytus dentalius - This worm was recorded for only a short period of time (from August through October 1977). A total of 71 and 265 specimens were found at stations 1 and 2, respectively, during the sampling periods. No specimens were collected at lower salinity stations (3 and 4) during this study (Table 2).

Podarke obscura - Like the worm, Autolytus dentalius, this species occurred rarely for a short period of time (from September through November 1977). A total of 34 specimens of this species were collected during the sampling period indicated. This worm was found exclusively at station 2 (Table 2).

Figure 13. Average number of <u>Neanthes succinea</u> at sampling stations.

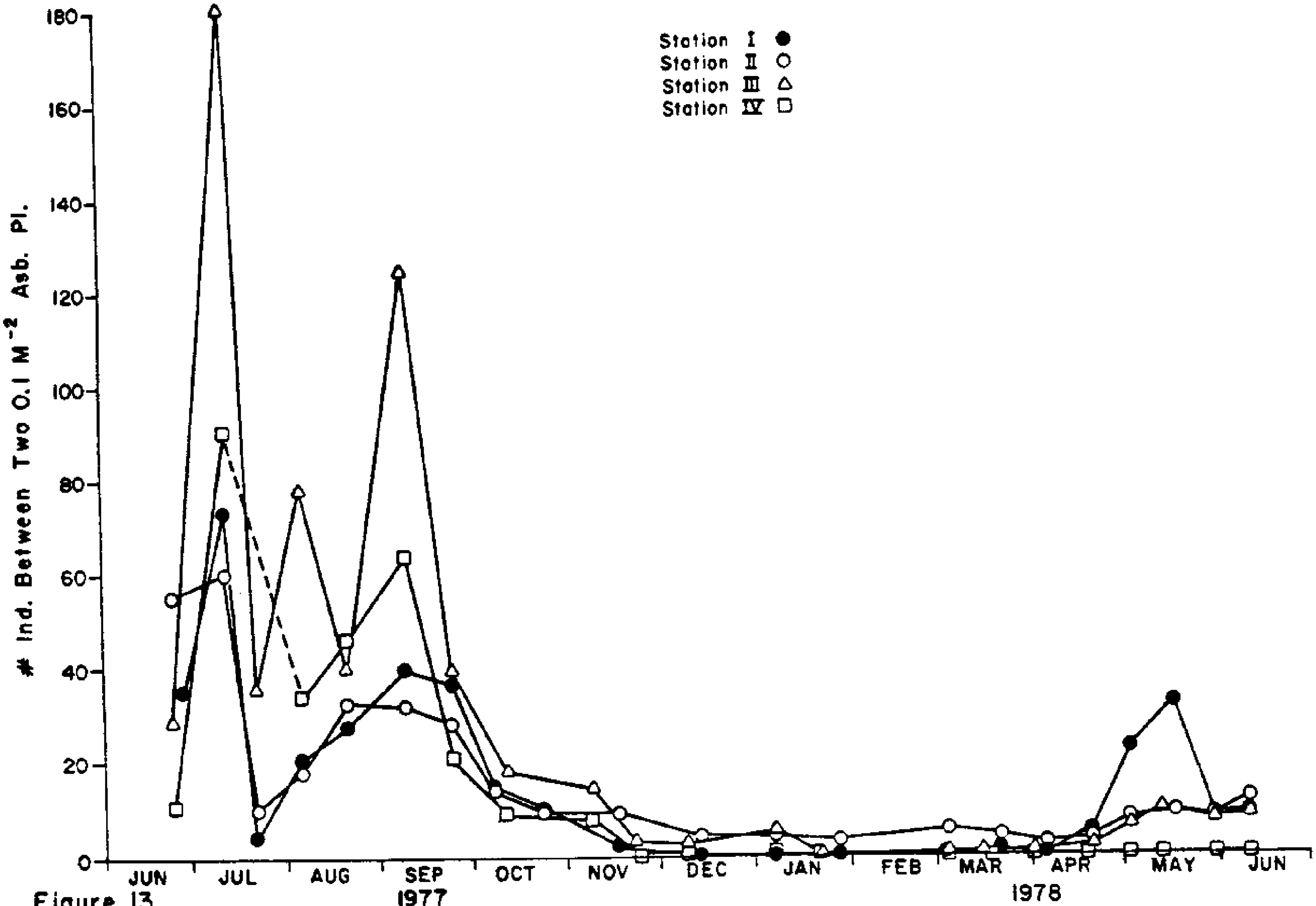

Station I ●
Station II ○
Station III △
Station IV □
180
160
140
120
100
80
60
40
20
0
Ind. Between Two 0.1 M⁻² Asb. Pl.
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 13.

Class Oligochaeta

Oligochaetes - The oligochaetes, which ranged approximately 2-3 mm in length, occurred at stations 1, 2 and 3 (Table 2). Most of them were found at station 1. The number of individuals of this class seemed to reach a peak between April 4 and April 19, 1978. Not a single specimen of this class was collected in 1977. The highest number of individuals of this class occurred on the upper surface of the sampling plates (134 0.1 m^{-2} asb. pl.) at station 1. Almost all of these worms tended to settle on the upper surface of the top level sampling plates. Only one specimen appeared on the bottom level plates.

Phylum Mollusca

Class Gastropoda

Thais haemastoma (Oyster drill) - The oyster drill, *Thais haemastoma*, was found only at station 2 in this study (Table 2). Only 14 specimens of *T. haemastoma* occurred at this station throughout the sampling periods.

Doridella sp. - An opisthobranch (*Doridella* sp.) was found only occasionally between July and November 1977 and between April and May 1978 at all stations (Table 2). A total of 36 individuals were collected during these periods of time.

Unidentified opisthobranch - This mollusk was a commonly occurring species at all stations (Table 2). Most of the organisms were collected from June through early November 1977. The greatest number of this mollusk encountered was 234 0.1 m^{-2} asb. pl. at station 1 between June 27 and July 12, 1977. With the onset of cooler waters, the number of individuals declined to almost zero. Not a single specimen was found at any stations between January 6 and March 31, 1978. Only a small number of individuals occurred from April through May 1978 at the stations. All specimens collected in this study were too small to identify.

Class Bivalvia

Crassostrea virginica (Eastern oyster) - A small peak of oyster spat set seemed to occur at stations 1 and 2 respectively from July 22 to August 5, 1977. The largest peaks of oyster spat set were seen at the two lower bay stations during the time period from September 8 to October 7, 1977 (Fig. 14-16).

Negligible oyster settings were observed at the upper bay stations, station 3 (East Fowl River) and station 4 (Great Point Clear) (Table 2). The average number of oysters (# spat m^{-2} day^{-1}) was less than 1 at these two stations (Fig. 16). The number of oyster set m^{-2} day^{-1} was calculated as follows:

$$\frac{\text{actual count} \times 100}{\text{\# days in sampling interval}}$$

Only 5 specimens of oyster spat were collected at both stations 3 and 4 during the entire oyster setting periods of this study. The average number of oyster spat set (# spat m^{-2} day^{-1}) was approximately 0.2 at these stations.

Since the highest spat set (78 m^{-2} day^{-1}) and the highest average oyster set (15 m^{-2} day^{-1}) were encountered at station 2, it is concluded that this station presented the best conditions for spat settlement.

Oyster spat demonstrated a preference for upper surface in deference to lower surface of the sampling plates in their setting. 433 out of 562 oyster spat (approximately 77%) were found on the upper surfaces of the asbestos plates used in this study.

Figure 14. Number of oyster spat set at station 1 at three different levels (surface, middle and bottom).

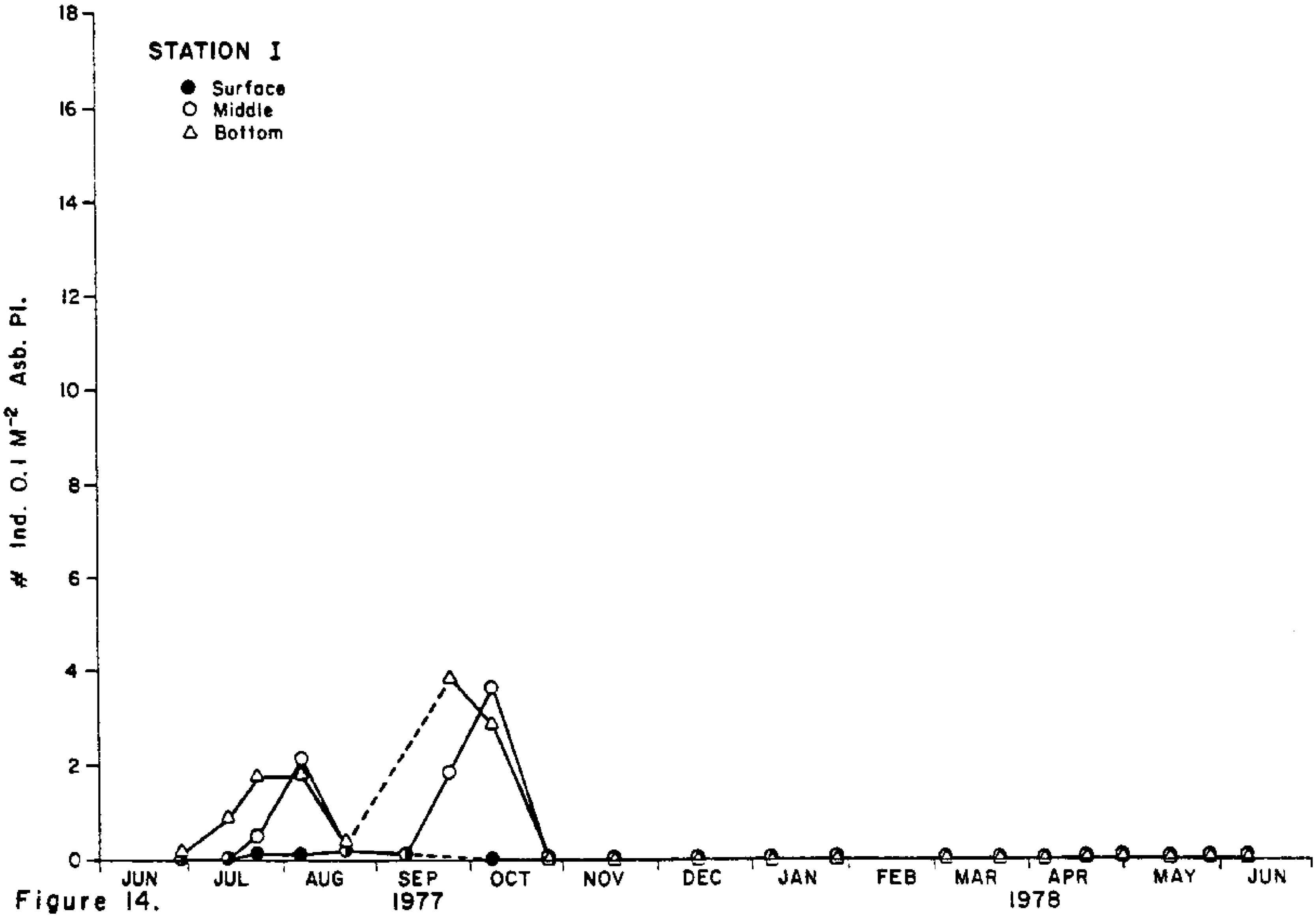

STATION I
Surface
Middle
Bottom
Ind. 0.1 M-2 Asb. Pl.
18
16
14
12
10
8
6
4
2
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978
Figure 14.

Figure 15. Number of oyster spat set at station 2 at three different levels (surface, middle and bottom).

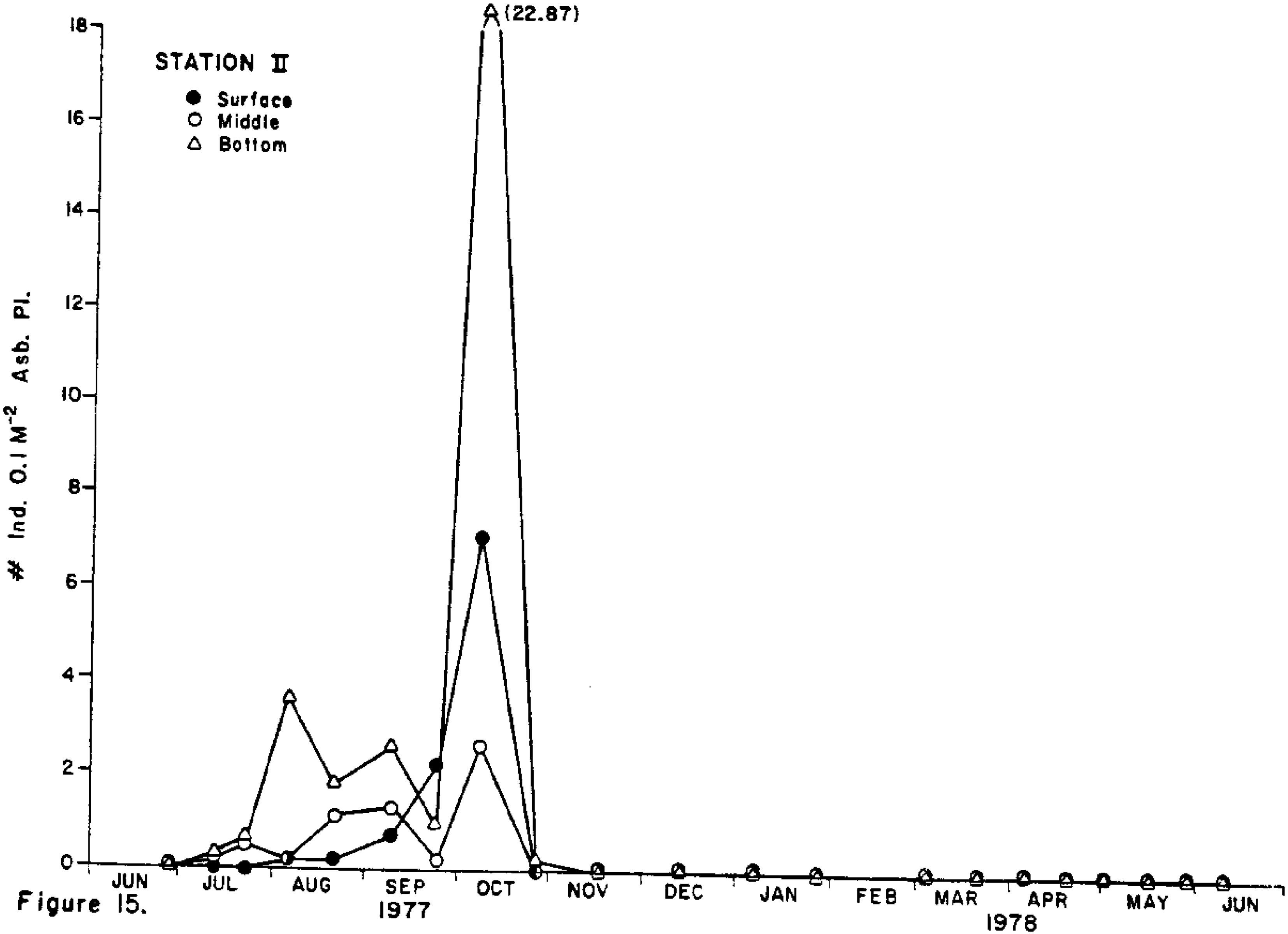

STATION II
Surface
Middle
Bottom
(22.87)
Ind. 0.1 M^{-2} Asb. Pl.
0
2
4
6
8
10
12
14
16
18
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 15.

Figure 16. Average number of oyster spat set (# ind. m^{-2} day^{-1}) at sampling stations. (Note vertical scale differences.)

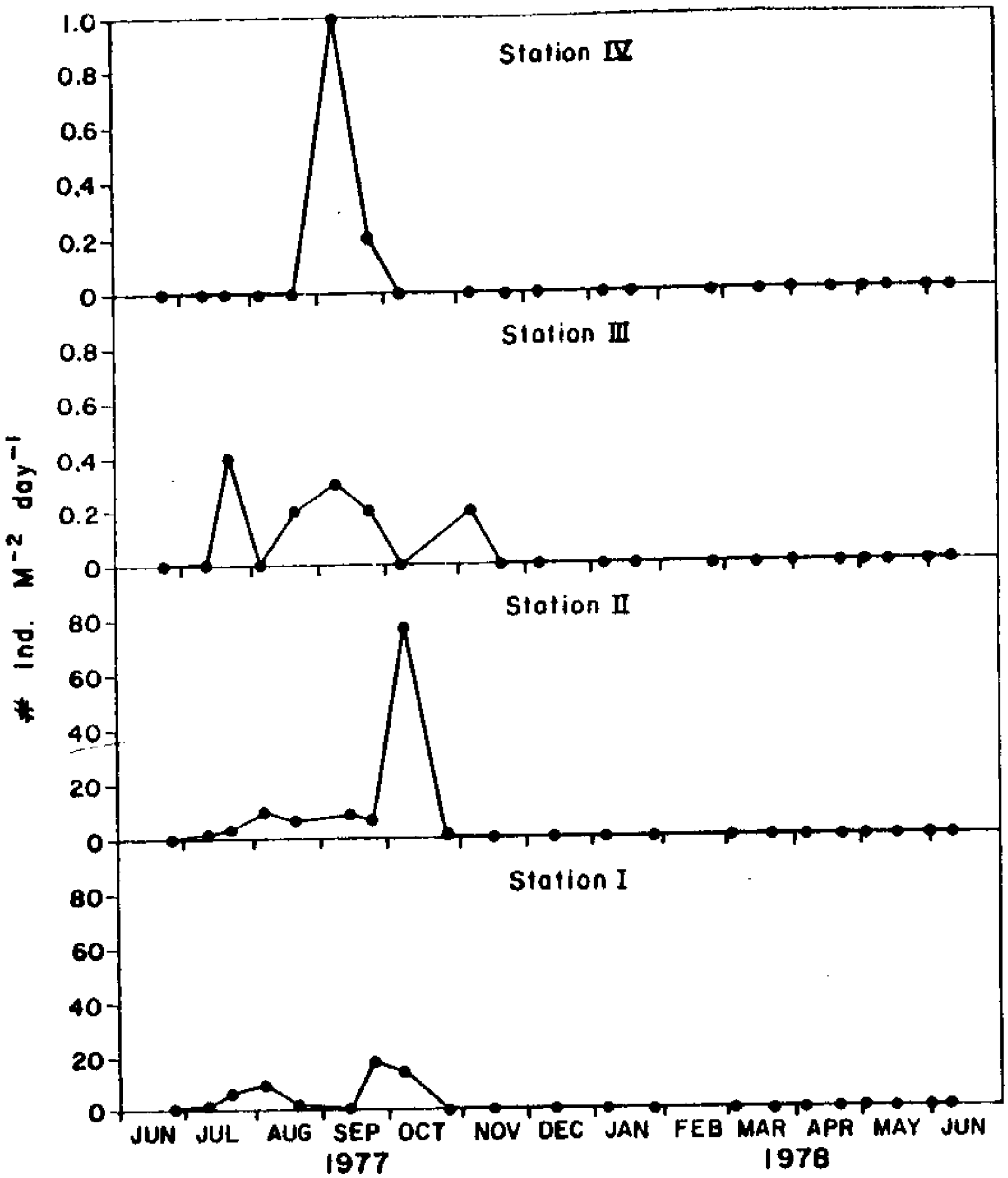

Station IV
Station III
Station II
Station I
Ind. M^{-2} day^{-1}
1.0
0.8
0.6
0.4
0.2
0
80
60
40
20
JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN
1977
1978

Figure 16.

Ischadium recurvum (Hooked mussel) - Only a small number of the hooked mussel were found throughout the study except June 1977 and January 1978 (Table 2). Almost all of the hooked mussels were juveniles (less than 10 mm).

Mytilopsis leucophaeata (Conrad's false mussel) - *M. leucophaeata* was found at station 4 exclusively (Table 2). Only 6 individuals of this bivalve mollusk appeared between May 12 and June 9, 1978 at this lower salinity station. Almost all of the Conrad's false mussels were juveniles (less than 10 mm).

Phylum Arthropoda

Class Crustacea

Balanus eburneus (Acorn barnacle) - *B. eburneus* was the dominant species at all stations and occurred throughout the sampling period (Table 2). Although pronounced peaks were recorded, year around spawning is suggested; juveniles (less than 1 mm class) were found on all sampling dates. Significant peaks of barnacle setting were found at stations 1, 3 and 4 between April 19 and May 12, 1978. The highest number of barnacles occurred at station 4 (10,300 m^{-2} day^{-1}) from May 1 to May 12, 1978; the second highest number of barnacles was found at station 1 (8,600 m^{-2} day^{-1}) during the sampling period from April 19 to May 1, 1978 (Fig. 17-21). The number of barnacle set m^{-2} day^{-1} was calculated in the same way as oyster set.

There existed a temporal difference in the peak periods of barnacle setting between the upper bay (lower salinity stations) and the lower bay stations (higher salinity stations) with the peaks of the settings at stations 1 and 2 occurring approximately 2 weeks earlier than at stations

Figure 17. Number of barnacle set at station 1 at three different levels (surface, middle and bottom).

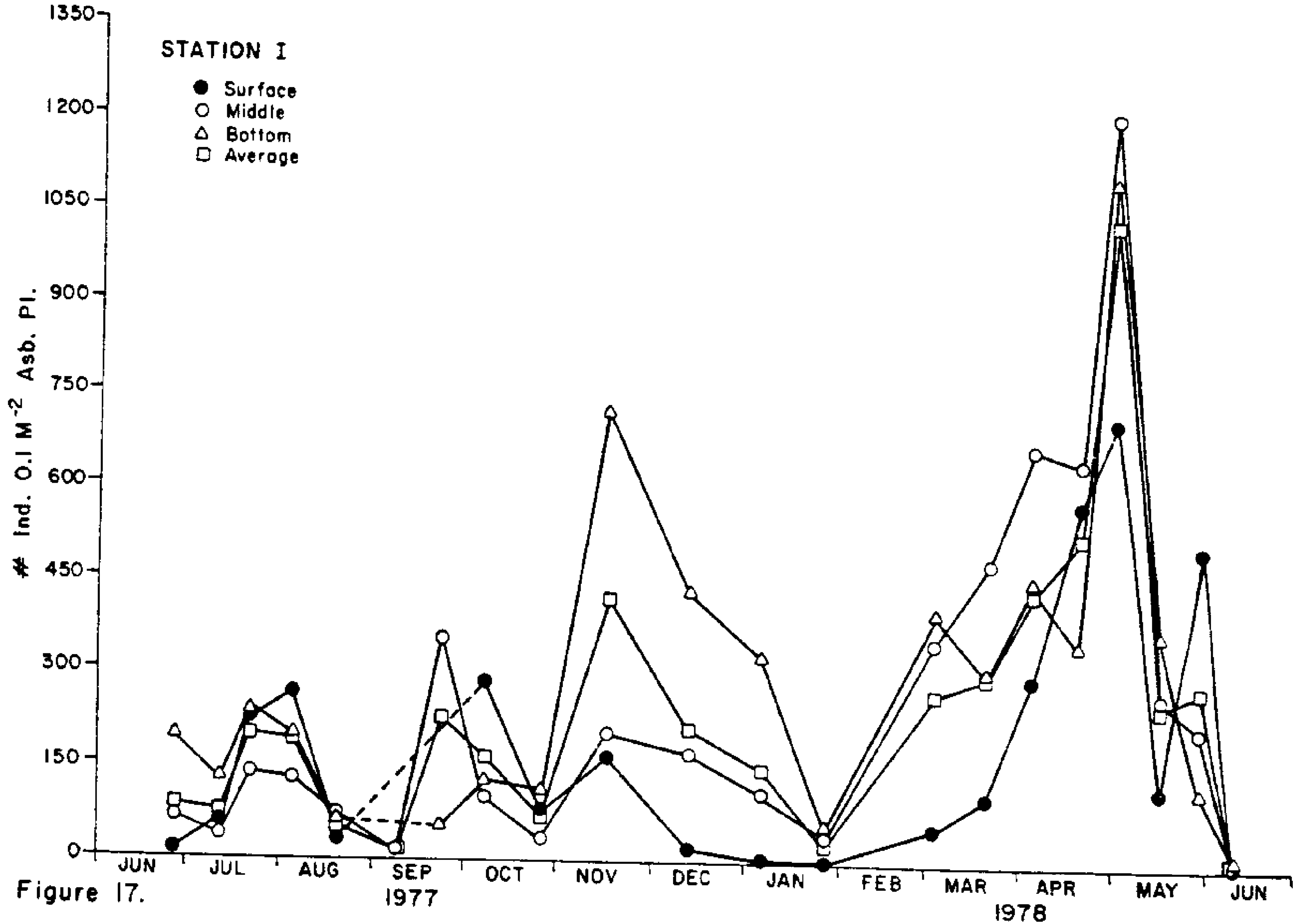

STATION I
Surface
Middle
Bottom
Average
Ind. 0.1 M-2 Asb. Pl.
1350
1200
1050
900
750
600
450
300
150
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 17.

Figure 18. Number of barnacle set at station 2 at three different levels (surface, middle and bottom).

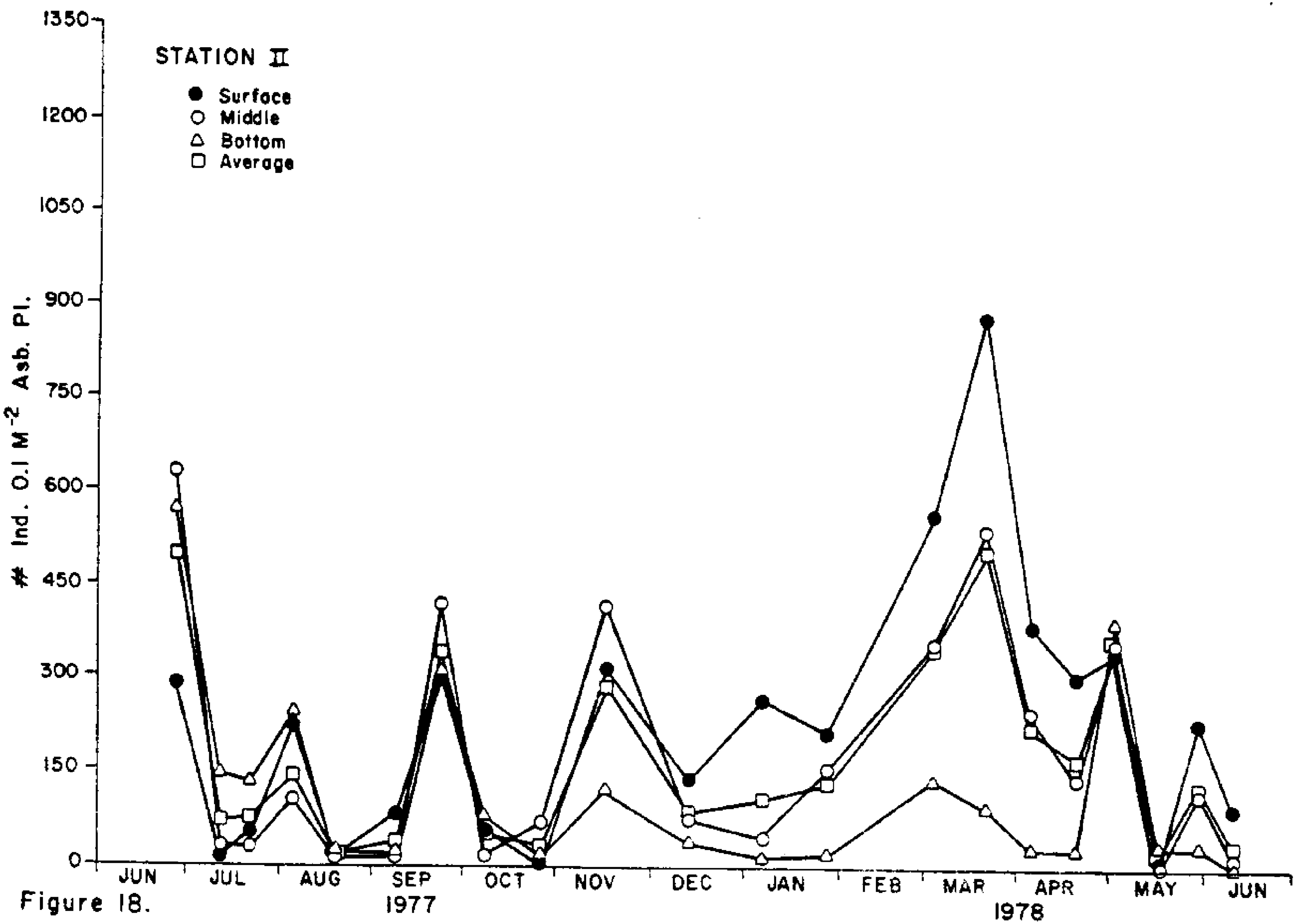
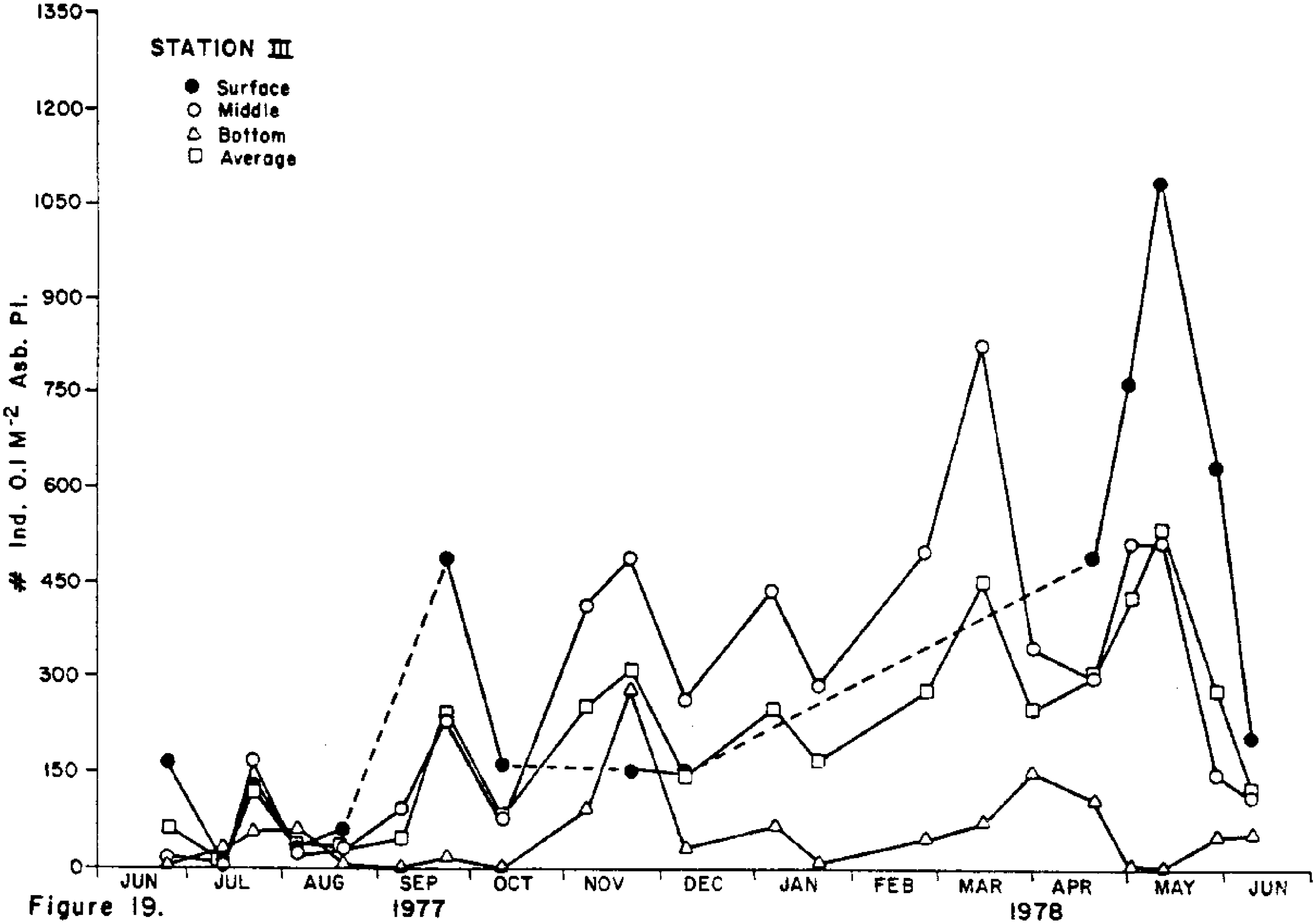

STATION II
Surface
Middle
Bottom
Average
Ind. 0.1 M-2 Asb. Pl.
1350
1200
1050
900
750
600
450
300
150
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 18.

Figure 19. Number of barnacle set at station 3 at three different levels (surface, middle and bottom).



STATION III
Surface
Middle
Bottom
Average
Ind. 0.1 M-2 Asb. Pl.
1350
1200
1050
900
750
600
450
300
150
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 19.

Figure 20. Number of barnacle set at station 4 at three different levels (surface, middle and bottom).

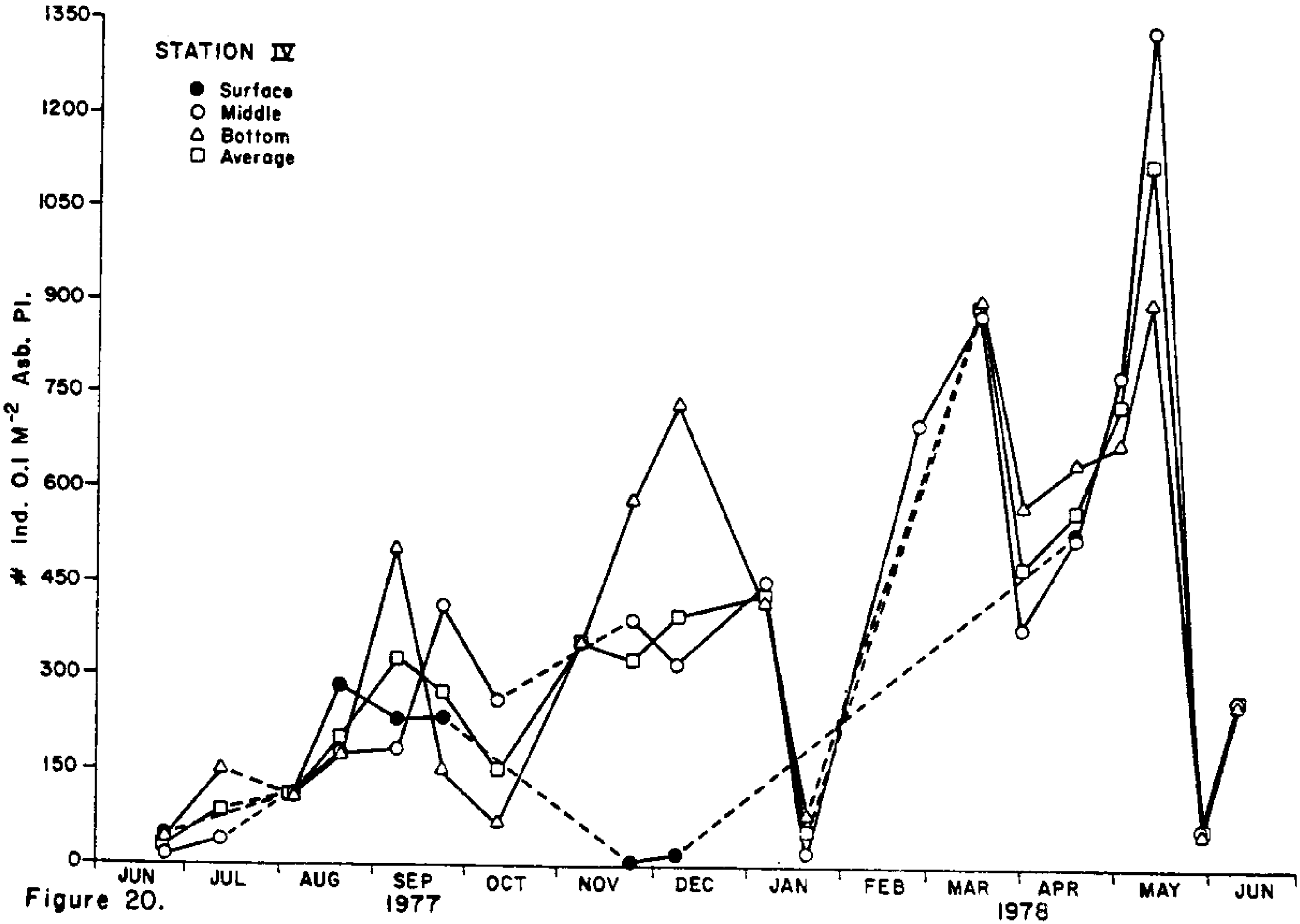
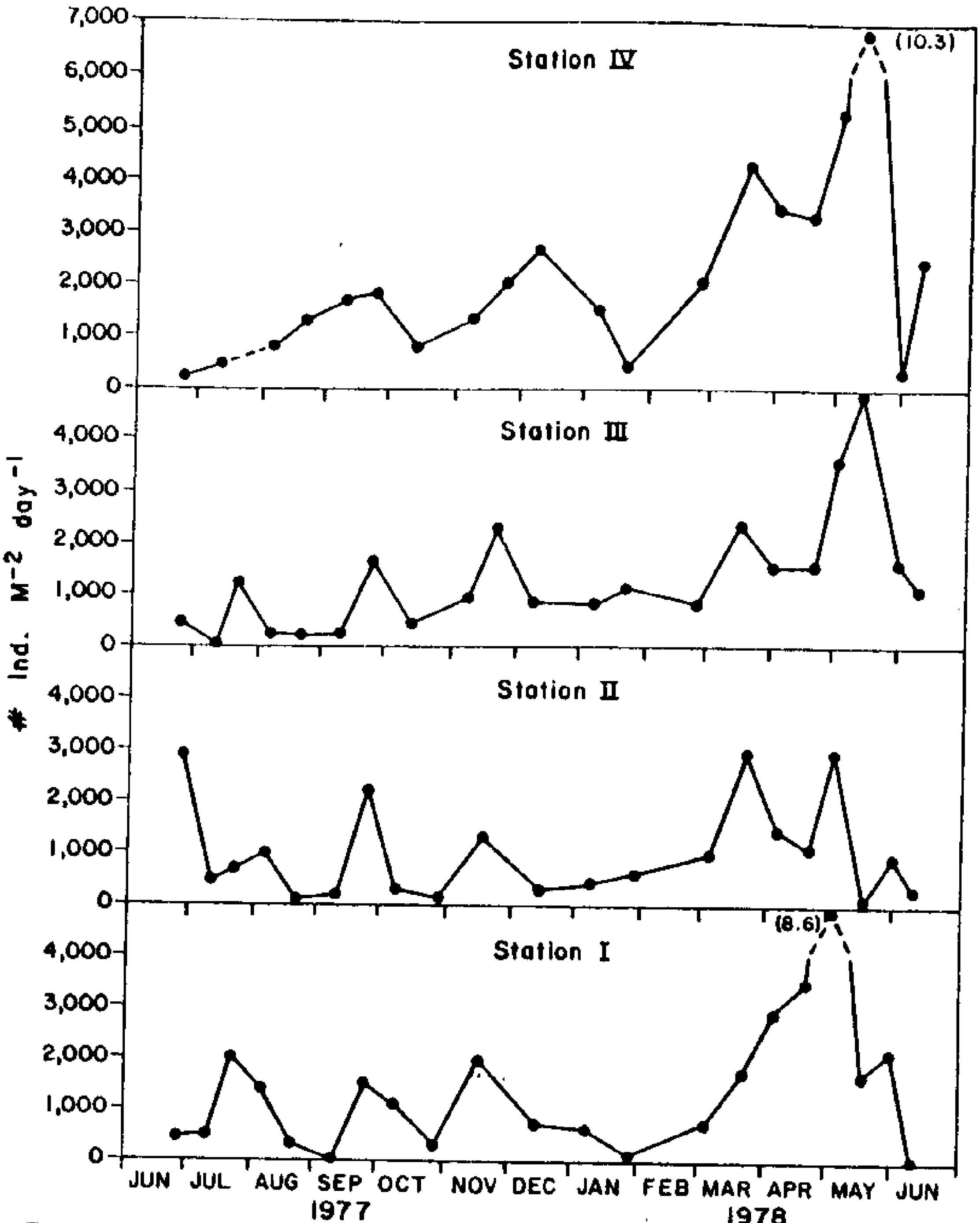

STATION IV
Surface
Middle
Bottom
Average
Ind. 0.1 M^{-2} Asb. Pl.
1350
1200
1050
900
750
600
450
300
150
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 20.

Figure 21. Average number of barnacle set (# ind. m^{-2} day^{-1}) at sampling stations.



Station IV
(10.3)
Station III
Station II
Station I
(8.6)
Ind. M-2 day-1
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN
1977
1978

Figure 21.

3 and 4 (Fig. 21). In contrast to oyster spat, more barnacles tended to settle on the under surface of sampling plates than on the upper surface of the plates. An average of 60% of the total number of barnacle settings occurred on the under surface of the plates.

Melita nitida and Melita sp. - The amphipods, M. nitida and Melita sp., occurred predominantly at the two lower stations, 1 and 2, of Mobile Bay (Table 2 and Fig. 22). Most of the individuals occurring at stations 1 and 2 were M. nitida; Melita sp. composed only 4 and 8% of the total Melita species at stations 1 and 2 respectively. Only 27 specimens of M. nitida occurred at station 3 during the entire sampling period and station 4 had only 1 specimen of each M. nitida and Melita sp. during the entire sampling period. The highest average number of M. nitida (# between two 0.1 m^{-2} asb. pl.) at station 1 was approximately 80 during late July 1977 and during late May 1978 respectively. After the first peak around July 1977, the number of M. nitida decreased dramatically to near zero around September 1977. Although they seemed to have small peaks, no pronounced appearance of these amphipods was found from September 1977 through March 1978. The number of these species suddenly increased after April 1978 and reached a peak around May 1978 at the lower bay stations (Fig. 22). The peak of the species at station 1, however, was more distinct than that of station 2 during this time period.

Gammarus spp. - These species occurred at lower salinity stations (3 and 4) exclusively (Table 2). A total of 18 specimens of Gammarus spp. were collected at the two stations; 4 specimens at station 3 and 14 at station 4. All of them were collected between March and May 1978.

Figure 22. Average number of *Melita nitida* and *Melita* sp. at station 1 and station 2.

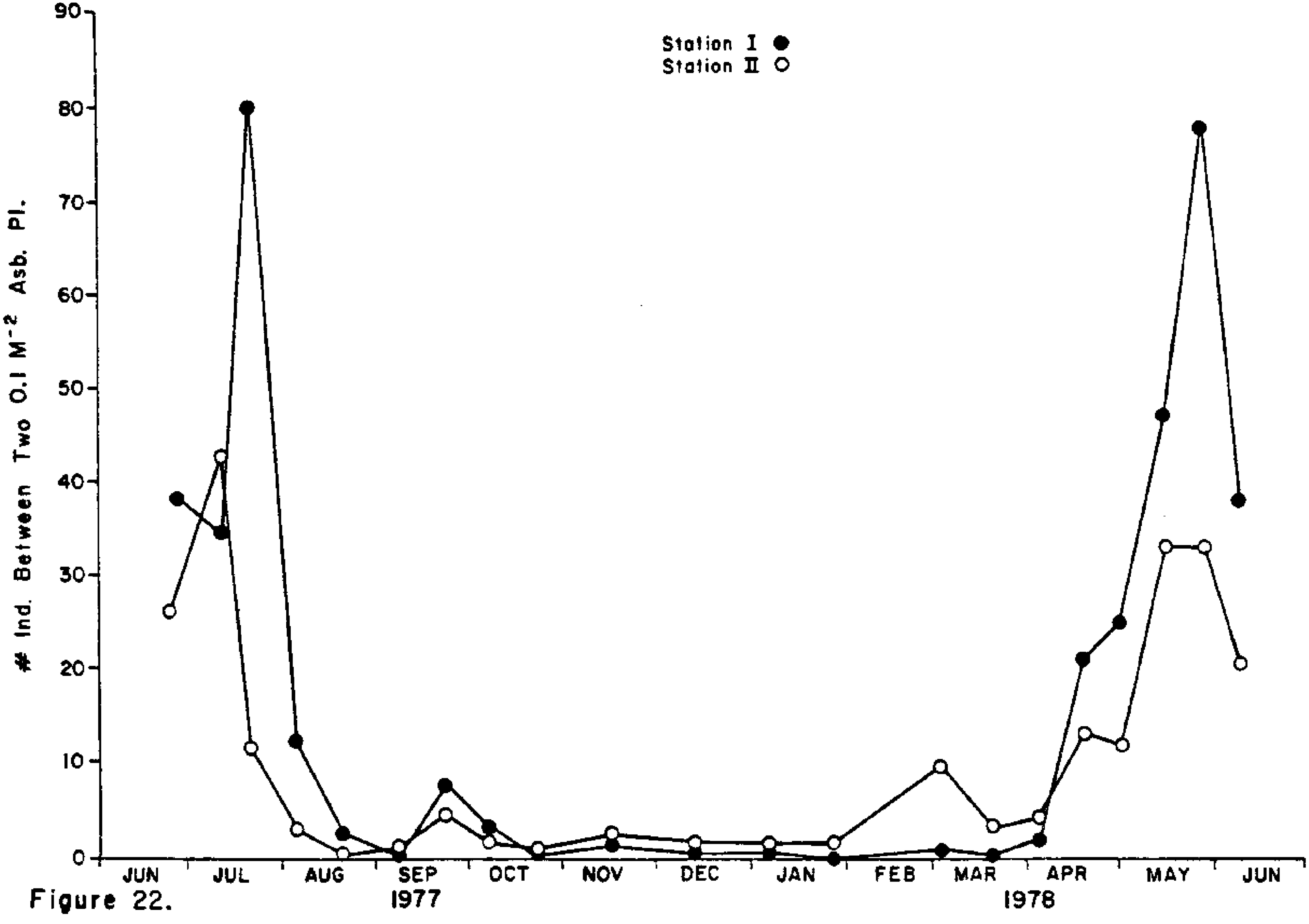

Station I ●
Station II ○
Ind. Between Two 0.1 M-2 Asb. Pl.
90
80
70
60
50
40
30
20
10
0
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1977
1978

Figure 22.

Grandidierella bonneroides - Three individuals of *G. bonneroides* were collected at the two lower bay stations (1 and 2) (Table 2). This amphipod occurred from December 1977 through April 1978.

Corophium lacustre - The highest number of *Corophium lacustre* occurred on the upper surface of the bottom level plates of station 3 between May 29 and June 9, 1978 (123 0.1 m^{-2} asb. pl.). The average number of *C. lacustre* at this station was 25 0.1 m^{-2} during this period of time. From April 1978, the number of this species tended to increase throughout June 1978 at station 3. No increase in the number of *C. lacustre* was observed at station 4, however, this species occurred continuously at this station from August 1977 to the end of the sampling period. On the other hand, individuals were not encountered continuously at stations 1 and 2.

Paracaprella cf. *pusilla* - This amphipod was found at lower bay stations only (1 and 2) from August through October 1977 and during late April 1978 (Table 2). A total of 56 specimens of *Paracaprella* were collected during the entire sampling period. During the sampling period from August 20 through September 8, 1978 the highest number of this species was found at station 2.

Eurypanopeus depressus (Mud crab) and *Callinectes sapidus* (Blue crab) - The juveniles of *E. depressus* and *C. sapidus* occurred at the four stations from June to October 1977. After that period, no crab juveniles were found at the upper bay stations (3 and 4). A small number of crab juveniles, however, were collected at the lower bay stations (1 and 2) throughout the sampling period (Table 2). More than 30 individuals of the megalopa stages of the blue crab, *C. sapidus* were collected exclusively at station 2 during the sampling periods from August

20 to September 23, 1977. Along with this species, several individuals of the megalopa stage of the xanthid mud crab, *E. depressus* were collected during the same period of time. Most specimens of the blue crab consisted of the megalopa stage, but the mud crab had both juveniles and megalopa. Not surprisingly, the mud crab, *E. depressus*, was found to be the most common and dominant crab in this study.

Class Insecta

Unidentified midges (Order Diptera) - These animals were found at the lower salinity stations (3 and 4) exclusively (Table 2). Only 2 specimens of midges were collected between November 7 and November 23, 1977. From April through June 1978, 12 specimens of the midges were found at these stations.

Phylum Bryozoa

Class Gymnolaemata

Membranipora sp. - Colonies of this encrusting bryozoan commonly occurred from June to November 1977 at all stations. No colony of *Membranipora* was found at the upper bay stations (3 and 4) from December 1977 through the end of the sampling period. At stations 1 and 2, however, it occurred continuously throughout the sampling period (Table 2).

In this study, the bryozoan colony covered a large part of the sampling plates and prevented other setting organisms from settling on those parts of the plates. In some cases, this species entirely covered barnacles and other settling organisms. Some single colonies of this bryozoan covered almost 1/5 of a plate; others only 1/100 of the plate. Larger sizes of the colonies of *Membranipora* were found most frequently at station 2. The sizes of the colonies at other stations, particularly at stations 3 and 4 seemed to be smaller than those at station 2.

The number of the bryozoan colonies settling on the under surface of the asbestos plate was approximately 53% of the total colonies.

Other miscellaneous organisms:

The eggs of Gobiesox strumosus (Skilletfish) - A number of skilletfish eggs were found on sampling plates, particularly on the under surface of lower plates at stations 1 and 2. From July through October 1977 and from April through May 1978 the eggs of this fish covered as much as 90% of the under surface of the plates. These fish eggs seemed to be an important space competitor in slowing or preventing the settings of other organisms in the same manner as the encrusting bryozoan, Membranipora sp.

Hypleurochilus geminatus (Crested blenny) - Blennid fishes were seen over all stations, but were more frequently and abundantly seen at stations 1 and 2. A specimen of Hypleurochilus geminatus was captured on November 16, 1977 at station 1. This species was sitting on a broken sampler of the middle level at this station when the sampler was removed from the water.

Data analyses

The highest value of H' (approximately 0.8) occurred at station 2 during September 1977 and May 1978. Values of H' less than 0.2 were recorded from November 1977 through April 1978 at all stations except station 2 (Fig. 23). Species diversity increased during May 1978 at stations 1 and 2, but showed little change at stations 3 and 4. The basic trend of values of H' over the study period showed a sinusoidal shape at each station. Higher values of H' corresponded to warmer months and lower values corresponded to cooler months (Fig. 23).

Figure 23. Species diversity (H') of each sampling period at sampling stations.

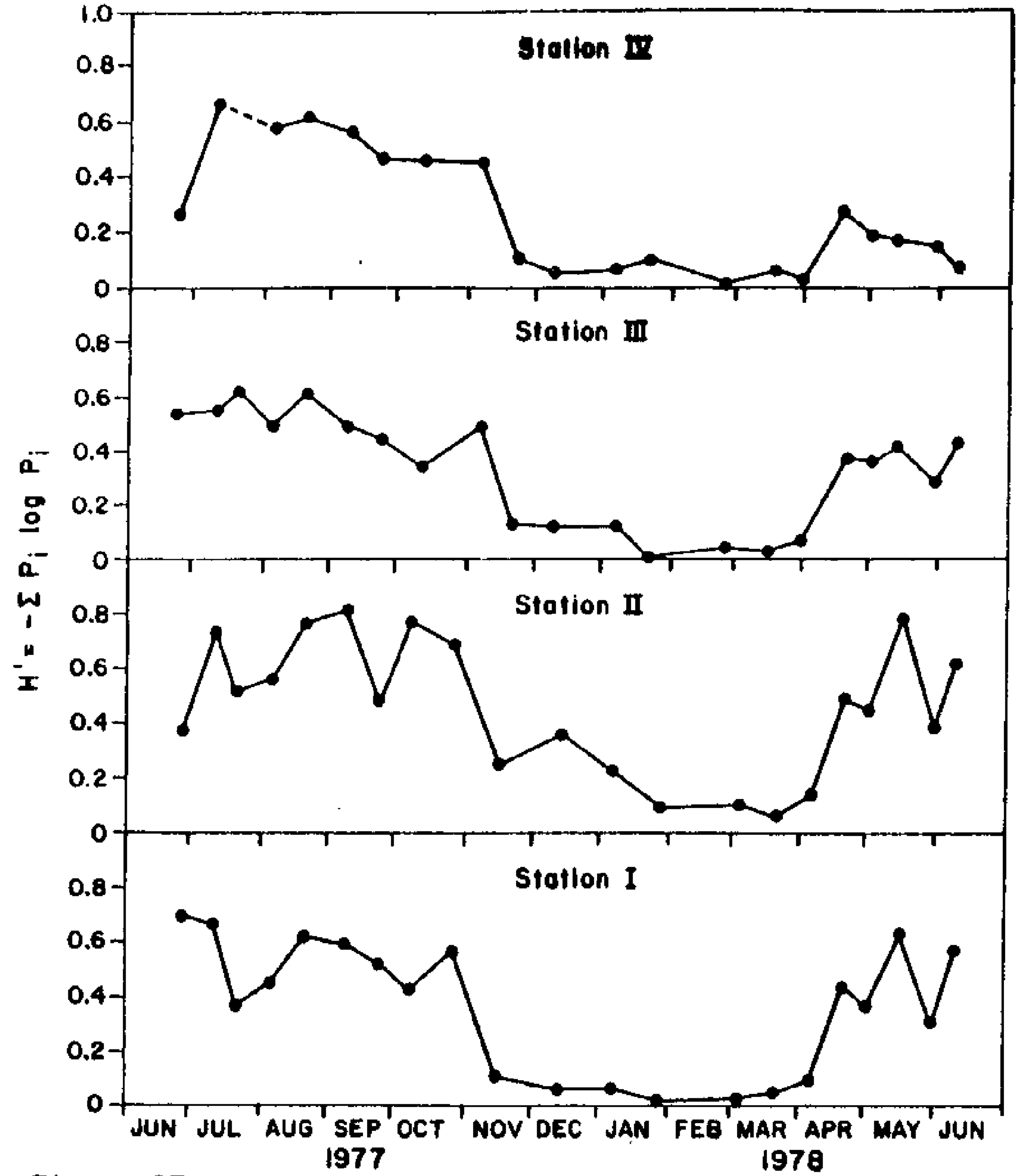

Station IV
Station III
Station II
Station I
H' = -Σ P_i log P_i
1.0
0.8
0.6
0.4
0.2
0
JUN JUL AUG SEP OCT NOV DEC JAN FEB MAR APR MAY JUN
1977
1978

Figure 23.

Differences in number of species at three levels (top, middle and bottom) were significant ($p < 0.001$). Differences in number of individuals at these levels were less significant than number of species ($p < 0.01$) (Table 3). The number of species at bottom levels was found to be highest, while the number at top levels was the lowest. As relatively large numbers of barnacles and *Polydora websteri* settled on all levels of the sampling plates (with few exceptions), the difference in the number of individuals seemed to be less important than the number of species. The differences in both number of species and number of individuals during sampling periods (time) were also significant at $p < 0.001$ and $p < 0.01$ respectively (Table 3).

Species diversity values (H') differed significantly ($p < 0.001$) with respect to location and time (Table 3). Water temperature did not seem to account for the difference in species diversity at different stations. Salinity, however, appeared to be a significant factor in influencing species diversity.

During the one year sampling period, stations 1 and 2 contained 19 and 21 taxa respectively. Lower taxa abundance was observed at stations 3 and 4 (15 and 16 taxa respectively). Although stations 1 and 2 had more species than station 3, the average values of H' at station 3 (0.55) was slightly higher than stations 1 and 2 (0.50). This was due to the additional occurrence of a large number of *Polydora websteri* and possibly to a relatively high number of *Corophium lacustre* at station 3. The lowest average value for H' was seen at station 4 (0.37).

Wilcoxon's test for two groups (upper surface and lower surface of plates) was used with respect to the number of individuals. The

TABLE 3. Statistical Analyses for Differences Between Levels, Stations, and Times for Number of Species, Number of Individuals, and Diversity (H').

Sources of variation		Community parameters: Number of species	Number of individuals	Diversity (H')
Levels	Between levels	$X^2 = 16.67$ $p < 0.001$	$X^2 = 11.14$ $p < 0.01$	
	Between times	$X^2 = 56.37$ $p < 0.001$	$X^2 = 46.08$ $p < 0.01$	
Stations	Between stations	$X^2 = 42.00$ $p < 0.001$	$X^2 = 14.40$ $p < 0.01$	$X^2 = 28.98$ $p < 0.001$
	Between times	$X^2 = 62.27$ $p < 0.001$	$X^2 = 40.97$ $p < 0.01$	$X^2 = 65.06$ $p < 0.001$

number of individuals settling on the upper surface of sampling plates was significantly different from that of the lower surface at station 1 ($p < 0.01$). No significant difference occurred in the number of individuals between the upper and lower surfaces of the test plates at stations 2 and 3 ($p > 0.01$). Station 4 showed a significant difference between surfaces ($p < 0.01$) (Table 4). Large numbers of barnacles settling on the lower surface of the plates could account for this difference because barnacles were the dominant species at station 4.

The results of Fager's SDN index indicated that all stations, particularly station 4 showed high skewness: values of 0.11 were calculated for stations 1 and 2, and values of 0.15 for station 3 and 0.07 for station 4. Since only one or two species accounted for more than 70% of the total number of individuals (low species equitability or species evenness) and low species richness was observed, low evenness occurred at all stations. Station 4 showed the lowest value of the index and correspondingly the settling of organisms at this station was relatively lighter than other stations. The barnacles which apparently dominated station 4 throughout the sampling period may have utilized all the available space on the sampling plates and thus reduced the space available to other competitors.

TABLE 4. The Result of Wilcoxon's Test for Two Groups (Number of Individuals on the Upper Surface and Lower Surface of Plates) at Sampling Stations.

Station 1	Station 2	Station 3	Station 4
Ts = 32	Ts = 114	Ts = 52	Ts = 14
$p < 0.01$	*NS	*NS	$p < 0.01$

*NS = not significant at $p = 0.01$

DISCUSSION

Historically, slight north-south thermal variation (approximately $1^{o}C$) has been observed in Mobile Bay with temperatures being progressively higher to the south; no lateral temperature variation was observed (McPhearson, 1970). According to the data from Schroeder (1976; 1977b), there were no recognizable differences in temperatures between stations 1 and 3 from July 1 through October 13, 1977, and no lateral temperature variation was observed at stations 3 and 4 from July 1 to November 11, 1977. Although trends in both north-south and lateral temperature variations seemed to exist at the sampling stations in this study, no distinct pattern emerged (Fig. 3-5).

McPhearson (1970) found that Mobile Bay and Mississippi Sound demonstrated vertical salinity stratification with seasonal and annual variation of intensity. Stratification was more pronounced in September through October with minima during March through April. Although vertical salinity stratifications were found in this study, no evidence of a seasonal or annual salinity gradient pattern was found (Fig. 6-8). Furthermore, McPhearson (1970) found that surface and bottom salinities in Mobile Bay were higher to the east of the ship channel than to the west and gradually increased from the head of the bay to the mouth. In this study, I found slight differences in the bottom salinities at station 3 and station 4 (higher to the east than to the west); no such differences were observed in the surface salinities at these two stations. Salinity difference existed between the upper and lower bay in this study: lower bay stations (1 and 2) were slightly higher than upper bay stations (3 and 4). If we consider the fact that the flood tide tends to the right (east) and the ebb tends to turn to the left (west) resulting in a counter-clockwise movement of Mobile Bay water (Austin, 1954; McPhearson, 1970), and that Main Pass is responsible for approximately 85% and Pass aux Herons for approximately 15% of the exchange of waters in and out of Mobile Bay (Hill and April, 1974), the salinity regime at the four stations is in agreement with what might be expected.

Historically, McPhearson (1970) reported that turbidity in Mobile Bay is somewhat greater to the west of the ship channel than to the east on all transects, and it may be attributed to the larger percentage of silt transported on the ebb tide. In this study, no noticeable difference in the turbidity (Secchi Disc visibility) was found between upper eastern (station 4) and western stations (station 3) throughout the sampling periods except in late July 1977 (Fig. 9). One of the lower bay stations, station 1, showed the lowest value of average Secchi Disc visibility (highest turbidity) among stations. As Pass aux Herons is responsible for approximately 15% of the exchange of the waters in and out of Mobile Bay (Hill and April, 1974), it might be expected that a strong current and the resultant well-mixing of water existed at this station. In addition to the current, relatively strong wind at this station may affect the mixing of water. In point of fact, we experienced difficulty in diving and lost several samplers due to the strong currents and frequent low visibility encountered at this particular station.

Orientation of setting surface is probably only one of many factors contributing to the setting behavior of metamorphosing larvae.

Other factors such as siltation, fouling, light, currents, gregariousness, type of surface, color of surface, and swimming position of larvae when setting have all been reported to affect setting (Shaw, 1967). Since so many factors are involved in the setting behaviors of oysters (Thorson, 1964; Crisp, 1967; Shaw, 1967; Lutz *et al.*, 1970), it is hard to single out one factor which can determine the setting pattern of oyster spat. However, light effect (Thorson, 1964) and gregariousness caused by secretion of a substance from the small oysters (Crisp, 1967) may be important factors in the resultant upper surface preference by oyster spat (approximately 77% of total oyster spat) in this study.

Hoese *et al.* (1972) reported approximately 20 oyster spat m^{-2} day^{-1} at a lower bay station corresponding to my station 1. They reported that the number of spat at a station corresponding to my station 2 was less than 5 m^{-2} day^{-1}; they did not observe a noticeable setting peak. According to Hoese *et al.* (1972), the maximum oyster set at a station corresponding to my station 3, one of the upper bay stations, was approximately 7 m^{-2} day^{-1}, and no oyster spat set was recorded at a station corresponding to my station 4, the other upper bay station. They found that the only large area where oysters set annually and survive in commercial quantities was in the vicinity of Cedar Point where average set was less than 10 oysters m^{-2} day^{-1}. The maximum set at station 1 was also low, and only the stations in Mississippi Sound had sets exceeding an average of 50 m^{-2} day^{-1}. Apparently the progressively larger sets seaward did not favor survival, probably due to progressively increasing predation associated with higher salinity.

I found that the highest number of spat on asbestos plates was found at station 2 (78 m^{-2} day^{-1}), and a significant peak of oyster spat setting occurred from September 23 to October 7, 1977. The number of spat at station 1 was 20 m^{-2} day^{-1} (Fig. 16). In this study, I found less than 1 oyster spat (0.4 m^{-2} day^{-1}) at station 3 during the entire oyster setting period. Less than 1 oyster spat m^{-2} day^{-1} also occurred at station 4 (Fig. 16). As the highest spat set (78 m^{-2} day^{-1}) and the highest number of average oyster set (15 m^{-2} day^{-1}) occurred at station 2, one of the lower bay stations, this station seemed to be the best place for oyster spat collection in Mobile Bay as far as this study was concerned.

May (1969) and Hoese *et al*. (1972) found that oyster setting intensity was bimodal and the greatest setting occurred from June through September in Mobile Bay and Mississippi Sound. In this study, I too encountered a bimodal setting pattern, but the greatest setting occurred from September through October (Fig. 14-16). Different areas might show characteristic patterns differing from one another and differing from season to season at the same location (McNulty, 1953; Andrews, 1954; Beaven, 1954; Loosanoff, 1966; Shaw, 1967; Moore and Trent, 1971). If we analyze the results of these workers, it becomes difficult to determine the time of oyster setting peaks and the intensity of oyster set even at the same area year after year. I believe that a longer study is needed in the lower bay area to determine the seasonal and spatial distribution, and to assess the productivity of the eastern oyster in this ecosystem.

Hoese *et al*. (1972) reported several stations with minor summer peaks of barnacle set, however the general pattern of a large spring peak and a small fall (September) peak was evident over the whole bay.

Unlike the results of Hoese et al. (1972) and other workers (Moore and Frue, 1959; Moore et al., 1974; Little and Quick, 1976), only one peak of barnacle setting occurred during spring (April and May) 1978 at each station (Fig. 17-21).

The results of Hoese et al. (1972) indicated that a peak of barnacle set (8,000 m^{-2} day^{-1}) occurred in early June at station 2. At station 1 more than 7,000 barnacles were found during May and August. They found a peak of barnacle sets (13,000 m^{-2} day^{-1}) during June at station 3. No noticeable setting period of barnacles (less than 5,000 m^{-2} day^{-1}) was observed at station 4.

I found that a noticeable peak of barnacle set occurred at station 1 from April through May 1978 (8,600 m^{-2} day^{-1}). However, no pronounced peak was observed at station 2 in this study (less than 3,000) (Fig. 21). Frequent coverings of skilletfish eggs on the sampling plates at station 2, particularly on the lower surface of the plates during April 19 through May 16, 1978 seemed to affect the number of the barnacle setting at this station. (This time period coincided with the peak period of barnacle set.) The occurrence of skilletfish eggs was observed from July through October 1977 at stations 1 and 2, and it reappeared from April through May 1978 at station 2 exclusively. In several cases, more than a half of part of the plates were covered with these eggs, and it appeared to be difficult for other setting organisms including barnacles to find space available for their setting on the plates. In this study, no pronounced peak occurred at station 3 although a relatively large set (5,000 m^{-2} day^{-1}) was found during May 1978 at this station. The highest peak of barnacle setting (10,300) occurred from May 1 through May 12, 1978 at station 4 (Fig. 21). This study showed that station 4 also had the lowest species diversity among stations and barnacles were dominant species throughout sampling periods at this station. Since the setting of organisms at station 4 was relatively lighter than other stations, the barnacles seemed to utilize all available space on the sampling plates thus reducing space available to other competitors.

According to Little and Quick (1976), Polydora websteri was very abundant and numerous in the Pensacola Bay system. Hoese et al. (1972), however, did not record this species in their work. In this study, this species occurred predominantly at the station 3 (East Fowl River) and at other stations to a lesser degree (Fig. 11 and 12). Station 3, one of the upper bay stations, was also found to have the heaviest accumulation of mud or silt and this may contribute to the colonization by this polychaete worm. Owen (1957) concluded that Polydora websteri was an abundant organism associated with oyster community and contributed to the formation of a poor environment and in most cases was indicative of such an environment. I believe that the sharp increase in the number of P. websteri at stations 1 and 2 as well as at station 3 during April and May 1978 was partly due to increased sedimentation by silt and/or increased organic detritus caused by relatively heavy river discharge resultant from the precipitation during previous weeks or months.

The smaller setting of oyster spat and barnacles than the previous study (Hoese et al., 1972), the increased abundance in the number of Polydora websteri throughout sampling periods and 7 small pieces of fine wire picked up on the sampling plates at station 3 may indicate that this area (East Fowl River) is experiencing poor environmental conditions.

Members of the amphipod genus Corophium use a hard substrate as a site for attachment of their tubes which also aid in the accumulation of sediment in the community (Maurer and Watling, 1973). According to Cory (1967), the amphipod, Corophium lacustre, constructed its fragile mud tubes on panels from early spring through November. Diminishing numbers of this species in a down-river direction corresponds with decreasing turbidity and vegetable detritus in the same direction. Barnard (1958) found that amphipods comprised one of the most abundant forms of fouling organisms in turbid water. Much of the flocculent detritus in the harbors resulted from domestic and industrial pollution, so that the luxuriant growth of the mat-forming organisms were biological indicators of these conditions when they were optimal and below toxic levels. According to him, amphipods (Corophium) and polychaetes (Polydora) were detritus feeders, flourishing only in those very turbid waters carrying organic detritus useful as food. The abundance of Corophium lacustre and Polydora websteri at station 3 (East Fowl River) are further presumptive evidence of the possible richness of organic materials and accumulation of heavy sediment associated with river discharge from the Mobile delta.

Hoese et al. (1972) found that a bryozoan, encountered at all stations and considered to belong to the genus Membranipora, seemed to be the second most abundant settling organism. Since this species formed large colonies asexually and allowed no other organism to settle on them, Membranipora was possibly an important summer competitor and slowed the setting of other species. In this study, the bryozoan (Membranipora sp.) covered sampling plates almost the year around, particularly from August through November 1977. In most cases, lower bay stations seemed to have a much heavier setting of the bryozoan than upper bay stations. No setting of this species occurred from March through May 1978 at the upper bay stations (3 and 4).

May (1968; 1971) found that the oyster drill, Thais haemastoma, was the most serious oyster predator in Alabama and severely restricted oyster distribution in the state. May and Bland (1970) mentioned that the distribution of T. haemastoma within the bay was regulated by salinity. Average salinities in excess of 15 ppt favored drill populations and their activity diminished when salinity was below 10 ppt. In this study, the lower bay stations, 1 and 2, showed higher average salinities (approximately 11 to 12 ppt) than the upper bay stations, 3 and 4 (approximately 6 to 8 ppt). The fact that only 14 specimens of the oyster drill were collected at station 2 indicates that its predation on oyster spat may be limited to some extent at the lower bay stations by low average salinity.

Salinity has been found to be a significant factor in species diversity (Gunter, 1961; Wells, 1961; Cory, 1967; Boesch, 1972; Maurer and Watling, 1973). Water temperature also appears to be one of the most important factors affecting species diversity (Gunter, 1961; Cory, 1964; Calder and Brehmer, 1966). A critical impact of temperature on the occurrence of number of species and number of individuals did occur during the winter of this study. Almost all stations tended to decrease both in number of species and number of individuals with decreased water temperature. Appearance of species also seemed to coincide with an increase in water temperature, however, no pronounced impact of increased temperature on the increase in number of species or number of individuals was observed for the summer season. Furthermore, water temperature does not seem to account for the difference in species diversities at different stations since no noticeable temperature variations were observed at the sampling stations in this study.

Station 2, one of the lower bay stations, showed the highest value of H' (approximately 0.8) during September 1977 and May 1978. This station also seemed to show the highest values of each H' throughout sampling period. At other stations, values of H' less than 0.2 were observed from November 1977 through April 1978 at all stations. Species diversity increased during May 1978 at stations 1 and 2, but showed little change at stations 3 and 4 (Fig. 23). In addition, species abundance at the lower bay stations, 1 and 2 (19 and 21 taxa respectively) was higher than at the upper bay stations, 3 and 4 (15 and 16 taxa respectively). A lower salinity station (3-East Fowl River), however, showed the highest H' (0.55) over the entire period.

The basic trend of seasonal values of H' over the study period showed a sinusoidal shape at each station. Higher values of H' seemed to be found during the period of warm temperatures and lower values during the cold season although exceptional cases occurred at each station (Fig. 23). Station 4 is an exception and did not show an increasing trend for values of H' during warmer season (May and June 1978).

For Fager's Scaled Standard Deviation (SDN) index, a value of 1.0 represents evenness and 0.0, extreme skewness (few species). The values of SDN index in this study ranged from 0.07 to 0.15 at all stations: values of 0.11 were estimated for stations 1 and 2, values of 0.15 for station 3 and 0.07 for station 4. Since the setting of organisms other than barnacles was relatively lighter at station 4 than at other stations, this station showed the lowest value (greatest skewness) of the index (0.07). The values from the SDN index correlate well with the average values of H' at each station. That is the trends in the SDN values closely parallel the trends exhibited by H'.

SUMMARY AND CONCLUSIONS

The seasonal and spatial settings of oysters, barnacles and other settling organisms on asbestos plates were studied experimentally in relation to temperature, salinity, and Secchi Disc visibility at four stations in Mobile Bay from June 10, 1977 to June 9, 1978.

1. A total of 26 taxa were collected during the entire sampling period.
2. Water column temperatures were near uniform (vertical gradients $< 2.2^{\circ}C$) throughout the study area except in four cases, station 2 on September 23, 1977, station 3 on September 8, 1977 and January 6, 1978 and station 4 on March 31, 1978, when vertical gradients reached 3.2, 3.1, 3.1 and $2.9^{\circ}C$ respectively. The thermal pattern observed over the study period was as follows: water temperatures reached $28-32^{\circ}C$ from June through August 1977 and then continued to decrease from the end of September until early February ($5^{\circ}C$); after which they tended to increase again until June 1978, showing a reverse form of a sinusoidal curve.
3. Both the number of species and the number of individuals on the sampling plates declined with decrease in water temperature. An increase in water temperature appeared to stimulate the appearance of both species and individuals. High temperature *per se*, however, did not always seem to be related to the increase in either the number of species or the number of individuals.
4. Although the depth around the study area was relatively shallow, the combination of river discharge and salt water intrusion resulted in

approximately 10 ppt difference in salinity between surface and bottom water on 3 study dates. A relatively strong current observed near the Dauphin Island Bridge may have precluded this salinity difference at station 1. In addition to the current, strong winds over these shallow oyster reefs probably contribute to the breakdown of the halocline. Higher salinities at the lower bay stations seemed to correlate with higher species diversities at these stations.

5. Higher turbidity values were expected in the upper bay because of the proximity of the Mobile River System, however turbidity maxima were recorded at the station 1 (Cedar Point Reef) and were probably due to relatively strong currents and wind-wave resuspension.
6. Bimodal peaks of oyster spat were seen at lower bay stations near Cedar Point Reef from July 22 to August 5, 1977 and from September 8 to October 7, 1977. The second peak was the largest. Bimodal peaks were not observed at upper bay stations.
7. A greater number of oyster spat were found to set on the upper surface of individual sampling plates rather than on the lower surface of the plates (approximately 77%).
8. Barnacles were found to be the dominant and most abundant species throughout sampling periods at all stations. A noticeable peak of barnacle set was found at each station between April 19 and May 12, 1978. A two week difference in peak period of barnacle setting between upper bay stations and lower bay stations occurred.
9. Although higher salinity stations (1 and 2) had more species and higher values of H' during each sampling period, these stations did not show the highest H' over the entire period. A lower salinity

station (East Fowl River) showed the highest H' (0.55) over the entire period. This may be attributed to the occurrence of a large number of Polydora websteri and the occurrence of a relatively higher number of Corophium lacustre.

10. Statistical analyses indicate that difference between levels (top, middle and bottom plates) and times (sampling periods) for number of species was more significant ($p < 0.001$) than similar analyses using number of individuals ($p < 0.01$). At two stations (1 and 4) the number of individuals settling on the lower surface of a plate was significantly higher ($p < 0.01$) than settling on the upper surface. Station 2 did not show this significant difference. This may have been due to the occurrence of skilletfish eggs and encrusting bryozoans which might have acted as important spatial competitors in slowing or preventing the settling of other organisms.
11. The analyses of difference between stations and times for species diversity (H') also showed these differences to be significant at $p < 0.001$.
12. Fager's SDN index (values 1 = 0.11; 2 = 0.11; 3 = 0.15; 4 = 0.07) indicated that all stations showed high skewness since only one or two dominant species contributed the majority of individuals at all stations.
13. The consistant appearance of (a) a large number of Polydora websteri, (b) relatively larger amounts of silt and clay covering almost all of the plates, (c) higher number of Corophium lacustre, and (d) several small pieces of fine wire picked up on the sampling plates at station 3 (East Fowl River) indicate that this station might have suffered poor environmental conditions.

LITERATURE CITED

Andrews, J.D. 1954. Setting of oysters in Virginia. Proc. Nat. Shellf. Assoc. 45: 38-46.

Austin, G.B. 1954. On the circulation and tidal flushing of Mobile Bay, Alabama. Part 1. Texas A&M. Res. Found. Proj. 24: 1-28.

Barnard, J.L. 1958. Amphipod crustaceans as fouling organisms in Los Angeles-Long Beach harbors, with reference to the influence of seawater turbidity. Calif. Fish and Game. 44(2): 161-170.

Beaven, G.F. 1954. Various aspects of oyster setting in Maryland. Proc. Nat. Shellf. Assoc. 45: 29-37.

Boesch, D.F. 1972. Species diversity of marine macrobenthos in the Virginia area. Chesapeake Sci. 13(3): 206-211.

Cairns, J., Jr. and K.L. Dickson. 1971. A simple method for the biological assessment of the effects of waste discharges on aquatic bottom-dwelling organisms. J. Wat. Pollut. Control Fed. 43(5): 755-772.

Cairns, J., Jr., G.R. Lanza, and B.C. Parker. 1972. Pollution related structural and functional changes in aquatic communities with emphasis on freshwater and protozoa. Proc. Acad. Nat. Sci. Phila. 124(5): 79-127.

Calder, D.R. and M.L. Brehmer. 1966. Seasonal occurrence of epifauna on test panels in Hampton Roads, Virginia. Int. J. Oceanol. & Limnol. 1(3): 149-164.

Cory, R.L. 1964. Environmental factors affecting attached macro-organisms, Patuxent River Estuary, Maryland. U.S. Geol. Survey Prof. Paper 475-D: D194-D197.

__________. 1967. Epifauna of the Patuxent River Estuary, Maryland, for 1963 and 1964. Chesapeake Sci. 8(2): 71-89.

Crisp, D.J. 1967. Chemical factors inducing settlement in Crassostrea virginica (Gmelin). J. Anim. Ecol. 36: 329-335.

Gaufin, A.R. and C.M. Tarzwell. 1952. Aquatic invertebrates as indicators of stream pollution. U.S. Public Health Repts. 67: 57-64.

Grigg, R.W. and R.S. Kiwala. 1970. Some ecological effects of discharged waste on marine life. Calif. Fish and Game. 56(3): 145-155.

Gunter, G. 1961. Some relations of estuarine organisms to salinity. Limnol. Oceanogr. 6(2): 182-190.

Hill, D.O. and G.C. April. 1974. Water resource planning for rivers draining into Mobile Bay. Part 1. Hydrodynamic and salinity models. BER Rept. No. 168-112. Univ. Ala. Bur. Eng. Res. pp. 1-69.

Hoese, H.D., W.R. Nelson, and H. Beckert. 1972. Seasonal and spatial setting of fouling organisms in Mobile Bay and eastern Mississippi Sound, Alabama. Ala. Mar. Res. Bull. 8: 9-17.

Holland, J.S., N.J. Maciolek, and C.H. Oppenheimer. 1973. Galveston Bay benthic community structure as an indicator of water quality. Contr. Mar. Sci. 17: 169-188.

Howmiller, R.P. and A.M. Beeton. 1971. Biological evaluation of environmental quality, Green Bay, Lake Michigan. J. Wat. Pollut. Control Fed. 43(1): 123-133.

Leathem, W., P. Kinner, D. Maurer, R. Biggs, and W. Treasure. 1973. Effect of spoil disposal on benthic invertebrates. Mar. Pollut. Bull. 4(8): 122-125.

Little, E.J. and J.A. Quick, Jr. 1976. Ecology, resource rehabilitation and fungal parasitology of commercial oysters, Crassostrea virginica (Gmelin), in Pensacola estuary, Florida. Fla. Mar. Res. Publ. 21: 1-81.

Loosanoff, V.L. 1966. Time and intensity of setting of the oyster, Crassostrea virginica, in Long Island. Biol. Bull. 130(2): 211-227.

Lutz, R.A., H. Hidu, and K.G. Drobeck. 1970. Acute temperature increase as a stimulus to setting in the American oyster, Crassostrea virginica (Gmelin). Proc. Nat. Shellf. Assoc. 60: 68-71.

Maurer, D. and L. Watling. 1973. Studies on the oyster community in Delaware: the effects of the estuarine environment on the associated fauna. Int. Revue ges. Hydrobiol. 58(2): 161-201.

May, E.B. 1968. Summer oyster mortalities in Alabama. Prog. Fish-Culturist. 30(2): 99.

________. 1969. Feasibility of off bottom oyster culture in Alabama. Ala. Mar. Res. Bull. 3: 1-14.

________. 1971. A survey of the oyster and oyster shell resources of Alabama. Ala. Mar. Res. Bull. 4: 1-53.

May, E.B. and D.C. Bland. 1970. Survival of young oysters in areas of different salinity in Mobile Bay. Proc. Southeastern Assoc. Game and Fish Comm. 23: 519-521.

McMahan, E.A. 1972. Relative abundance of three marsh-floor organisms in a sewage-affected marsh and in a sewage-free marsh. J. Elisha Mitchell Sci. Soc. 88(2): 61-65.

McNulty, J.K. 1953. Seasonal and vertical patterns of oyster setting off Wadmalaw Island, S.C. Contr. Bears Bluff Laboratories. 15: 1-17.

McPhearson, R.M., Jr. 1970. The hydrography of Mobile Bay and Mississippi Sound, Alabama. J. Mar. Sci. Ala. 1(2): 1-83.

Moore, D. and L. Trent. 1971. Setting, growth and mortality of Crassostrea virginica in a natural marsh altered by a housing development. Proc. Nat. Shellf. Assoc. 61: 51-58.

Moore, H.B. and A.C. Frue. 1959. The settlement and growth of Balanus improvisus, B. eburneus and B. amphitrite in the Miami area. Bull. Mar. Sci. Gulf Carib. 9(4): 421-440.

Moore, H.B., H.D. Albertson, and S.M. Miller. 1974. Long-term changes in the settlement of barnacles in the Miami area. Bull. Mar. Sci. 24(1): 86-100.

Owen, H.M. 1957. Etiological studies on oyster mortality. II. Polydora websteri Hartman (Polychaeta: Spionidae). Bull. Mar. Sci. Gulf Carib. 7(1): 35-46.

Reish, D.J. 1957. The relationship of the polychaetous annelid Capitella capitata (Fabricius) to waste discharges of biological origin. In: C.M. Tarzwell, ed., U.S. Public Health Serv., Biological problems in water pollution. pp. 195-200.

__________. 1961. The use of the sediment bottle collector for monitoring polluted marine waters. Calif. Fish and Game. 47(3): 261-272.

Ryan, J.J. 1969. A sedimentologic study of Mobile Bay, Alabama. Contr. Sedimentological Res. Lab., Fla. State Univ. 30: 1-110.

Schroeder, W.W. 1976. Physical environment Atlas of Coastal Alabama. Mississippi-Alabama Sea Grant Program: 75-034. 250 pp.

__________. 1977a. Physical environment Atlas of Coastal Alabama. Mississippi-Alabama Sea Grant Program: 75-034 (1977 Supplement).

__________. 1977b. The impact of the 1973 flooding of the Mobile River System on the hydrography of Mobile Bay and east Mississippi Sound. Northeast Gulf Sci. 1(2): 68-76.

__________. 1977c. Sea truth and environmental characterization studies of Mobile Bay, Alabama, utilizing ERTS-1, Data Collection Platforms. Remote Sens. Environ. 6: 27-43.

Shannon, C.E. and W. Weaver. 1949. The mathematical theory of communication. Univ. Illinois Press, Urbana. 117 pp.

Shaw, W.N. 1967. Seasonal fouling and oyster setting on asbestos plates in Broad Creek, Talbot County, Maryland, 1963-65. Chesapeake Sci. 8(4): 228-236.

Sokal, R.R. and F.J. Rohlf. 1969. Biometry. W.H. Freeman and Co., San Francisco. 776 pp.

Thorson, G. 1964. Light as an ecological factor in the dispersal and settlement of larvae of marine bottom invertebrates. Ophelia. 1(1): 167-208.

Wells, H.W. 1961. The fauna of oyster beds, with special reference to the salinity factor. Ecol. Monogr. 31(3): 239-266.

Wilhm, J.L. and T.C. Dorris. 1968. Biological parameters for water quality criteria. BioScience. 18(6): 477-481.

APPENDIX A

Water temperature, salinity and Secchi Disc visibility at four sampling stations over the study period.

Date	Stations	Water temperature (^oC)			Salinity(ppt)			Visibility (m)
		surface	middle	bottom	surface	middle	bottom	
6/10/77	1	28.8	28.2	28.2	22.4	22.9	22.0	0.75
"	2	27.5	26.9	27.1	21.1	22.7	18.8	1.25
6/11/77	3	29.8	28.7	29.7	12.8	12.5	11.4	1.25
"	4	29.9	28.3	30.5	13.4	13.8	11.2	1.25
6/27/77	1	29.4	29.3	29.2	25.1	25.2	25.1	0.25
"	2	31.5	30.5	32.1	24.5	24.8	23.7	0.75
6/24/77	3	31.9	31.2	31.0	11.5	12.5	10.8	1.25
"	4	31.0	31.0	30.5	10.7	10.7	11.2	1.25
7/12/77	1	29.1	29.2	29.4	15.2	17.0	17.3	1.0
"	2	29.1	28.2	29.1	14.5	15.6	16.1	1.25
"	3	28.7	28.4	29.5	10.1	10.5	16.1	1.75
"	4	28.6	28.7	29.2	12.1	12.1	13.6	1.75
7/22/77	1							1.50
"	2							2.25
"	3							1.75
"	4							2.75
8/5/77	1	28.4	28.5	28.7	15.1	14.9	14.8	0.50
"	2	27.6	27.7	29.6	14.1	17.4	16.7	0.75
"	3	28.1	28.3	28.7	9.4	10.2	8.8	1.50
"	4	28.3	27.8	27.7	14.2	14.8	13.0	1.50
8/20/77	1	30.2	30.1	30.0	9.7	10.3	10.1	1.25
"	2	29.8	30.1	29.8	7.8	12.8	16.7	1.25
"	3	29.7	29.4	29.8	7.0	7.2	9.8	1.50
"	4	29.3	29.3	29.0	8.6	8.4	8.2	1.0
9/8/77	1	29.1	29.0	29.0	17.9	18.3	19.4	0.75
"	2	29.3	28.3	29.8	16.5	25.1	26.0	1.25
"	3	28.4	28.0	31.2	12.2	17.1	16.5	1.25
"	4	27.8	27.8	28.2	12.9	12.8	14.5	1.0
9/23/77	1	28.6	28.7	28.7	10.6	11.0	11.0	0.75
"	2	28.3	28.2	31.3	9.5	13.5	14.0	1.50
"	3	28.3	27.9	28.3	4.4	5.9	4.9	0.75
"	4	27.4	27.5	27.4	14.3	13.9	15.2	1.25
10/7/77	1	22.4	22.8	23.2	11.9	11.7	12.4	0.50
"	2	23.0	22.8	23.1	11.7	11.6	12.4	1.25
10/11/77	3	21.5	21.2	21.2	7.7	9.0	8.2	1.0
"	4	21.9	23.0	23.1	7.8	11.9	11.8	1.0
10/26/77	1	21.1	21.0	21.4	10.0	9.8	10.1	0.75
"	2	21.5	20.9	21.3	7.9	8.7	12.8	1.25
"	3	22.6	20.8	21.6	4.3	4.8	8.9	1.0
11/7/77	3	17.7	18.7	18.0	7.0	6.6	8.8	1.0
"	4	19.6	19.7	20.2	4.4	5.1	9.4	1.25
12/13/77	1	10.8	10.3	11.0	5.7	5.7	5.6	0.75
"	2	9.5	9.5	10.1	4.3	4.5	7.5	0.75
12/8/77	3	12.0	11.9	12.1	3.6	3.5	3.1	0.25

APPENDIX A (continued)

12/8/77	4	10.9	11.0	11.0	1.2	1.1	1.0	0.25
1/6/78	1	11.9	12.1	12.5	9.8	10.5	11.0	1.25
"	2	11.1	10.8	11.5	7.3	11.2	9.3	1.0
"	3	9.9	9.3	12.4	5.9	6.1	5.3	1.25
"	4	11.0	10.7	11.1	8.7	10.1	8.9	1.0
1/27/78	1	7.6	7.6	9.5	1.0	--	--	0.50
"	2	7.9	7.3	7.6	1.0	--	--	0.50
1/21/78	3	5.2	--	6.7	--	--	4.6	0.25
1/20/78	4	5.8	5.8	5.8	--	--	--	0.50
2/10/78	3	5.5	5.3	5.0	2.5	2.5	2.3	0.50
"	4	5.2	6.3	6.3	2.2	11.9	11.6	0.50
3/3/78	1	13.3	13.3	13.1	7.7	14.2	14.3	0.50
"	2	13.4	13.3	13.6	9.3	11.9	12.5	1.0
2/24/78	3	--	--	--	5.5	--	--	1.0
"	4	--	--	--	4.0	--	--	0.50
3/20/78	1	15.2	15.3	15.3	3.7	3.7	3.7	0.25
"	2	15.3	15.3	15.2	3.2	3.2	3.4	0.50
3/15/78	3	18.1	17.2	16.8	2.0	2.5	2.7	0.25
3/17/78	4	15.0	15.2	14.4	1.2	2.1	2.2	0.25
3/31/78	3	17.6	17.4	17.1	3.6	3.6	3.7	1.0
"	4	18.8	15.9	16.1	4.0	9.2	9.7	0.50
4/4/78	1	23.5	23.4	23.3	9.3	9.3	9.6	1.25
"	2	22.6	22.3	22.2	9.2	9.4	11.4	1.25
"	3	22.4	21.9	21.8	5.9	5.9	5.9	0.75
"	4	22.0	21.9	20.2	4.1	4.3	5.4	0.75
4/19/78	1	25.1	25.1	25.1	10.5	10.5	11.1	0.50
"	2	24.6	24.6	24.6	10.9	10.7	11.6	0.50
"	3	26.5	26.4	26.4	1.1	1.1	1.0	0.50
4/17/78	4	24.5	24.1	23.8	4.4	4.6	6.6	0.75
5/1/78	1	24.8	24.1	24.2	16.5	17.1	17.1	0.50
"	2	23.5	22.8	22.7	18.3	20.1	19.7	0.50
"	3	22.5	22.6	22.5	6.9	7.2	8.1	0.50
"	4	24.0	23.9	23.1	2.2	2.2	2.5	0.25
5/16/78	1	23.8	23.8	23.9	2.0	--	--	0.25
"	2	24.1	24.1	24.5	1.0	--	--	0.25
5/12/78	3	--	--	--	0.0	--	--	0.25
"	4	23.6	23.5	23.5	0.0	--	--	0.25
5/29/78	1	29.3	28.8	28.9	1.9	1.6	1.7	0.50
"	2	29.0	28.1	28.3	1.8	2.4	2.5	0.75
"	3	29.3	29.3	28.9	1.1	1.1	1.1	0.50
"	4	28.1	27.3	27.1	0.8	1.1	0.9	0.50
6/9/78	1	29.8	29.0	28.7	5.1	7.8	7.8	0.25
"	2	29.8	28.1	28.1	4.6	6.5	7.7	0.25
"	3	28.7	28.0	27.9	2.1	2.5	2.6	0.25
"	4	28.7	27.8	27.7	1.7	1.9	2.2	0.25